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NEWER SURGICAL METHODS OF TREATING DISEASES OF THE VASCULAR SYSTEM*

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PHILADELPHIA

THE flow of the blood through the normal channels of the body is associated with factors so variable as to render the hydrokinetic interpretation of the circulation difficult or impossible. Alterations in the rate, force and capacity of the heart; constant changes in the contractile and elastic walled blood vessels; variable influences from without the blood vessels from muscles, respiratory movement, gravity, atmospheric pressure and position in space introduce such a multitude of constantly changing factors as to baffle the investigator who attempts accurately to evaluate the forces involved in the circulation of the blood. Fortunately, there are certain basic hydraulic laws upon which the surgeon may depend for guidance. One of the most important is relationship of the rate of flow of a liquid passing through a tube to the pressure the liquid exerts upon the walls of the tube or the "wall pressure." The wall pressure varies inversely as the velocity of the liquid. Narrow the tube at certain points and thereby increase the velocity and at these points the wall pressure is reduced. Dilate the tube in certain areas and there the wall pressure is increased. Thus, where an artery is narrowed, as by an end to end anastomosis, the blood exerts less strain upon the arterial wall. As an artery progressively dilates, as from an aneurysm, the current through the dilated portion is slowed, but the wall pressure increases. Conversely if nothing retards the velocity of a liquid through a vessel, no pressure will be exerted upon the walls of the vessel. Indeed, under certain conditions, a negative wall pressure will be present. A thin rubber tube will carry water at a pressure of 60 kg. or more per square centimeter and will not be distended if the rate of flow is not impeded. Tie for example the wrist of a thin rubber glove over a high pressure water spigot. Cut off the ends of several fingers and turn on the water at full pressure. The glove does not distend, but rather collapses against the rapidly moving stream of water. There has been no reduction in velocity of the stream and no wall pressure. Attempt to reduce the velocity by tying one or more of the open fingers of the glove. As the velocity is impeded, the glove becomes distended and may soon burst. Ligate one of the larger arteries of the body. The current, despite the collateral circulation, is slowed or arrested, and the vessel tends to dilate both proximal and distal to the point of ligation. How frequently has a proximal or a distal ligation for an aneurysm precipitated the rupture of the sac. Even the Greek surgeon, Antyllus, in the second century seems to have appreciated this better than some of our modern surgeons, for not content

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with a proximal and distal ligation, he also opened the sac and obliterated it by packing. Philagrius evidently also realized the inefficiency of ligation for aneurysm just as Percival Pott did in the 18th century.

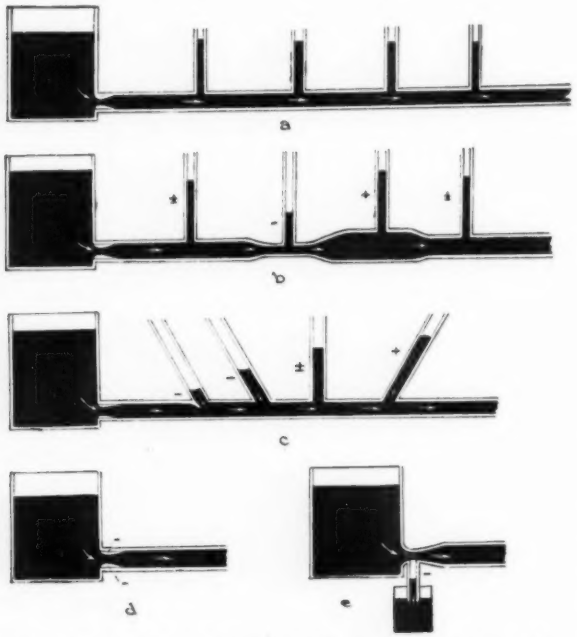

Fig. 1. Conventional diagrams illustrating factors that influence wall pressure from liquids flowing through tubes.

Even the positive method of producing coagulation in an aneurysmal sac by wiring and electrolysis as devised by Moore and Corradi is a dangerous and uncertain method. Of 39 cases of aneurysm treated by wiring in the Johns Hopkins Hospital, nearly 50 per cent of the patients died in from one day to two months and none was known to be living at the time of Reed's report in 1926. From a hydrodynamic point of view it is evident that ligation or wiring for aneurysm is harmful. As slowing of the current of blood increases the pressure sustained by the vessel walls, we have turned to methods for increasing the flow of blood through the aneurysmal sac as the most feasible means of decompressing inaccessible aneurysms. For aneurysms of the thoracic aorta, we have divided the common carotid artery and internal jugular vein in the neck, and having ligated the distal ends have united the cardiac ends of the vein and artery. Thus, a bypass is provided, permitting the blood of the aneurysm to escape from the high pressure arterial system into the low or negative pressure of the descending vena cava. In other words, a constant arterial leakage is provided from the aneurysm and the adjacent vessels. Due to this leakage, the blood passes more rapidly through the aneurysm, the wall pressure of which is reduced. The systolic blood pressure falls, the aneurysm becomes smaller, the auricles of the heart fill in shorter time and by "the law of the heart" the rate is reduced. The pulmonary arteries carry partially oxygenated blood

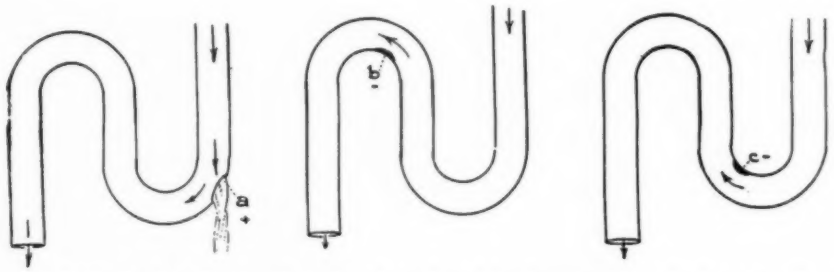

Fig. 2. Wall pressure from liquids flowing in tubes is reduced by increase in velocity or reduction in caliber of tube, and increased by reduction in velocity or increase in caliber of tube. At points of bending increased pressure is exerted on convexity, decreased pressure on concavity of tube.

Ligation for aneurysm, so often unsatisfactory, occasionally gives relief by causing thrombosis within the sac. The obliteration of an aneurysmal sac by thrombosis is, however, always uncertain; the clot rarely becomes organized and not infrequently melts down or gives rise to embolism.

and the respirations are slowed. The strain upon the arterial system both under excitement or repose is lessened and the

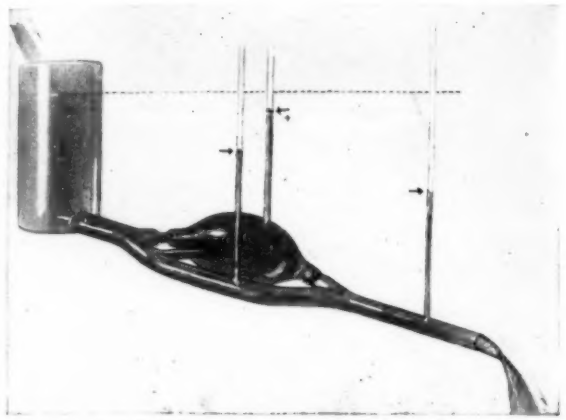

Fig. 3. Proximal and distal ligation for aneurysm reduces flow through sac; therefore, is followed by increased pressure upon walls of aneurysm, often leading to enlargement and rupture.

danger of enlargement and rupture of the aneurysm is decreased. This operation for thoracic aneurysm I first used in 1925. Since that time about fifty carotid-jugular anastomoses have been done by various surgeons. I have performed the operation nine times without operative mortality. In aneurysms of the aorta, there has been marked relief of pain. The first patient with an enormous aneurysm that had perforated the thoracic wall had a reduction in the diameter of the sac, was enabled to do light work and lived over four years finally dying of a chronic myocardial disease. The second patient after having been confined to bed by angina for eighteen months is relieved and is doing her housework; in the third, the aneurysm had perforated the posterior wall of the chest, yet the operation has also been followed by relief from pain. A recent fourth patient also shows improvement. In three other patients the operation was used to improve the pulmonary circulation in advanced bilateral pulmonary tuberculosis. One of these patients has shown marked improvement; two (Negroes) who were in the last stage of the disease made good operative recoveries but died after some weeks from the progress of the disease. The operation was also tried on two patients for apparently hopeless types of heart

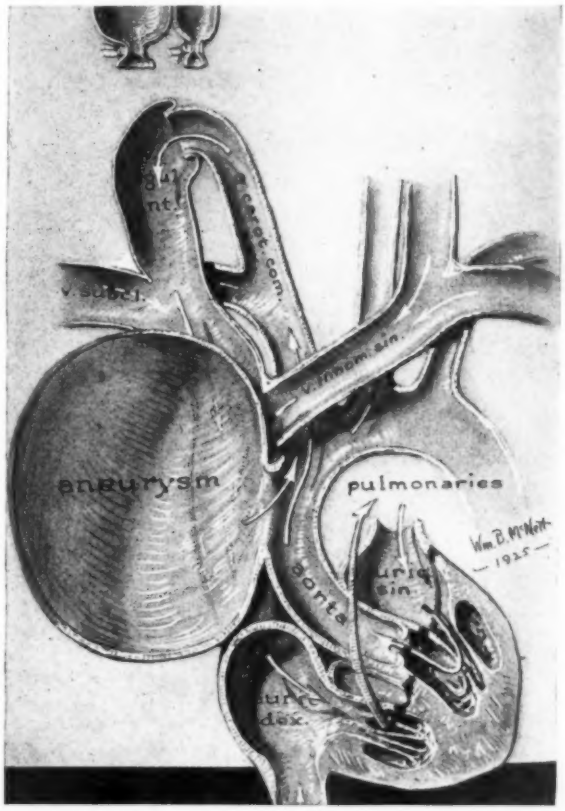

Fig. 4. Carotid jugular anastomosis for decompression of an aneurysm of the thoracic aorta. Artery and vein are divided, distal ends ligated and proximal or cardiac ends united, end to end, by suture. (From author's Text Book of Surgery. Saunders.)

disease. In a case of malignant endocarditis, little effect either favorable or unfavorable was observed. In a patient with chronic cyanosis from a supposed congenital stenosis of the pulmonary artery, the effects of the operation were masked by an advanced and widespread pulmonary tuberculosis.

It is believed that the operation has hydrodynamic merit in stenotic lesions of the heart and possibly also in cases of patent foramen ovale to balance the pressure in the right heart against that in the left. In mitral or pulmonary stenosis by increasing the velocity of blood through the heart, the output is increased. In angina the fall in aortic pressure may give

relief as was strikingly shown in the case of aneurysm, previously mentioned.

For intracranial aneurysms which may

Fig. 5. Incision for carotid-jugular anastomosis. Aneurysm of descending aorta perforating ribs posteriorly.

temporarily improve under ligation and then progress to a fatal issue, we suggest a direct method of decompression by an arteriovenous anastomosis. The operation not only eliminates a large source of blood supply to the aneurysm, but also provides a large arterial leak from the aneurysm back to the heart. The common carotid artery and jugular vein, on the side of the aneurysm, are divided and the cerebral end of the artery is united to the cardiac end of the vein. The cerebral end of the vein and the cardiac end of the artery are tied. Experimenting for me on dogs, Burnett has found no evidence of cerebral degeneration after the operation. The highly skilled surgeon may select the less accessible internal carotid instead of the common carotid artery. For various aneurysms of the trunk, anastomoses between the subclavian, the axillary or the iliac artery and the contiguous vein may be considered.

In any case, a lateral anastomosis be-

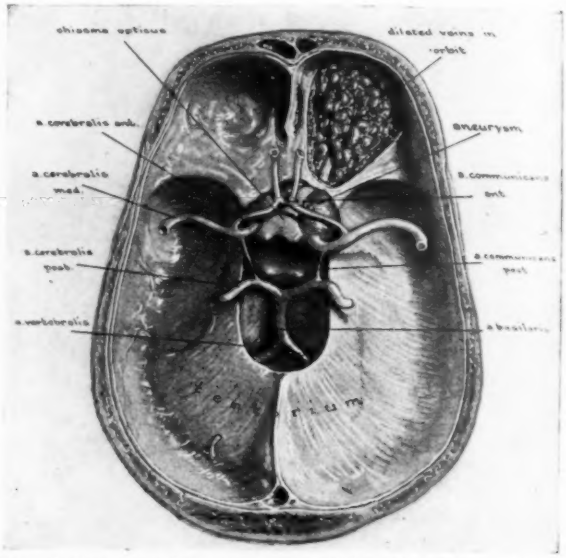

Fig. 6. Intracranial aneurysm with enlarged vessels of right orbit causing proptosis.

tween the artery and vein should not be used, as such a union produces very dangerous hydraulic effects upon the circulation. For example, the spontaneous rupture of a small aneurysm at the base of the aorta into the adjacent descending vena cava drives back the venous blood into the brain and so interrupts the cerebral circulation as usually to cause death in from seven to nine days.

Arteriovenous communications often follow injury, especially penetrating or gunshot wounds. In many cases, however, there is no history of an injury. The force of the arterial blood produces a distinct sac between the artery and the vein, or greatly dilates or elongates the veins forming an arterial varix. From the side to side communication, the arterial blood enters the vein, interrupts the venous current which is in part driven back toward the periphery especially during systole. During diastole, by the elastic rebound of the venous walls, venous blood may pass through the opening into the artery and by the succeeding systole be carried into the capillaries. The condition is associated

therefore with marked venous congestion and stasis in the affected veins and capillaries, and a mixture of both arterial and

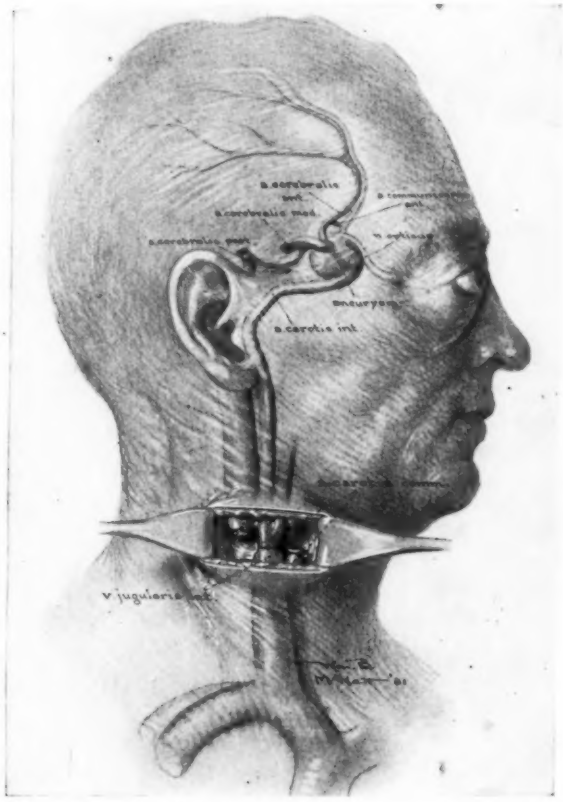

Fig. 7. Operation for intracranial aneurysm by carotid-jugular anastomosis. Cephalic end of divided carotid artery upon side of aneurysm is united to cardiac end of divided deep jugular vein. Cephalic end of vein and cardiac end of artery are ligated. Operation not only eliminates one large source of blood supply to aneurysm, but supplies a large exit under negative pressure for decompression and drainage of sac.

venous blood in both veins and arteries. The arterial blood tends to return to the body through the bypass and veins without going through the capillaries so that the nutrition of the tissues suffers. When an extremity is affected it becomes swollen, cyanotic, cold and often painful. There is widespread pulsation of the dilated peripheral veins. Pigmentation, necrosis, hemorrhages, ulceration and gangrene may occur. If the artery is ligated proximal to the anastomosis, the condition is made worse. Less arterial blood reaches the periphery, and through collateral channels the arterial blood passes through the arterial-venous fistula and returns to the body. The affected limb therefore is continuously being bled of its arterial

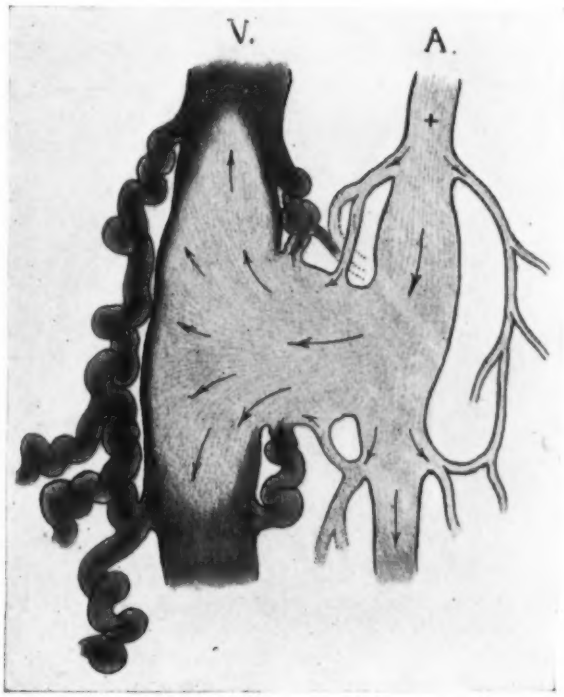

Fig. 8. Side-to-side arteriovenous communications produce great enlargement with pulsation of tributary veins. As indicated in diagram, during systole arterial blood enters vein, interrupting and reversing venous current.

blood. Ligation of the artery both proximal and distal to the fistula usually also fails to relieve the condition due to the very free anastomoses. After ligation of the artery and the vein, both above and below the fistula, the swelling usually quickly subsides, the ulcers heal and recovery follows. Only exceptionally does the quadruple ligation fail to block all collateral channels. A more ideal operation, when practicable, is to separate the artery and the vein and accurately close the opening in each with the removal of any intervening sac, or to resect the artery and vein at the site of the fistula, with an end to end anastomosis of each vessel. Such theoretically desirable operations may be very difficult or practically impossible. Matas has suggested that the fistulous opening be closed by sutures introduced

through an opening made in the vein, the incision in the vein being finally closed.

In cirsoid aneurysms greatly distended

Fig. 9. In arteriovenous communications, during diastole, rebound of distended veins forces venous blood through fistula into artery, an added factor in reducing nutrition of part.

and pulsating veins occur from an arteriovenous fistula about the head. By excising the large vessels connected with the fistula, the condition is relieved. The location of the fistula may be determined by finding the point where the bruit is loudest and where pressure best stops the pulsation and causes collapse of the enlarged vessels.

Circulatory deficiency of the extremities may be due to vasomotor spasm, thickening of the arterial walls (arteriosclerosis), pressure from without (cervical rib, callus or tumor) or thrombosis or embolism

Table I

CIRCULATORY INSUFFICIENCY OF EXTREMITIES

1. Cardiac	Myocardial, Valvular, Conductive	Rest, Recumbency, Digitalis, Quinidine, CO_2-O Thyroidectomy.
2. Arterial	External Pressure	Remove Cervical Rib, Tumor.
	Thrombus, Embolus	Embolectomy.
	Vascular Spasm	Sympathectomy, Adrenal Denervation(?).
	a. Adventitia	Division.
	b. Media, c. Intima	Development of Collateral Circulation: (a) Ligation or Occlusion of Veins. (b) Intravascular Injections.
3. Capillary		Radiant Light, Heat, Baths. Exercise. Increase of Blood Volume.
4. Venous		Recumbency, Support, Sclerosing Injections.

Fig. 10. Areas of necrosis in leg of young girl from arteriovenous communication in thigh.

within the artery. A relative insufficiency may be due to venous engorgement (varicose veins) or cardiac disease.

In the spasmatic type of obstruction, such as occurs in Raynaud's disease, interruption of the sympathetic nerve supply by periarterial sympathectomy, ramisectomy or ganglionectomy is indicated. Of these operations, the periarterial sympathectomy is least dependable.

For types of partial obstruction, operations on the sympathetic system are occasionally useful and should be considered even in Buerger's disease, when the intravenous injection of typhoid bacilli or other test for vasospasm is followed by a marked rise in the temperature of the affected part. It is believed that undue credit has been given to periarterial sympathectomy from the improvement which so often follows in a limb with deficient circulation, when the patient is placed at rest in bed with the leg elevated. Especially is this true when a relative cardiac insufficiency is the precipitating factor. Under such a condition, a surprising but temporary improvement may follow the operation due entirely to a favorable influence upon the heart from the enforced post-

operative rest and position. In certain cases of partial occlusion of the arteries of the leg or arm relative compensation may be obtained by improving the output of the heart by regulated rest and the use of heart tonics.

In the treatment of the other forms of circulatory failure in the extremities, mechanical obstructions should first receive attention. A cervical rib should be removed or the scalenus anterior divided, as suggested by Adson. Tumors should be excised. Embolectomy has in a small percentage of cases been successful and should be considered at the onset of thrombosis. The toxic causes that produce arterial occlusion, especially tobacco, lead, syphilis, should as far as possible be eliminated.

An increase in blood volume seems often to give a degree of relief. Marked improvement has followed the use of intravenous injections of physiologic saline, hypertonic saline, sodium citrate solution (Steele), sodium iodide solution, and other liquids. It is quite possible that the added bulk of water introduced into the circulation deserves especial credit.

In Buerger's disease and in arteriosclerosis improvement of the collateral circulation is most desirable. The ligation of the main vein of the limb often seems of value in causing an enlargement of the collateral vessels.

Oppel of Petrograd has long contended that an adrenalinemia which causes an exfoliation of the endothelium of the arteries is responsible for the thrombosis of endarteritis obliterans and has urged as an appropriate treatment a reduction in the functional activity of the medulla of the suprarenal by operation. The operation of denervation of the adrenals now being used by Crile for other conditions we therefore have tried for Buerger's disease. A wider experience is required however, before any conclusion is reached.

Vascular anastomosis for the relief of circulatory deficiency of the extremities has thus far failed to improve the condition. An end to end union between the central ends of the main artery and the peripheral ends of the vein does not improve the circulation. The arterial blood in a measure drives back the venous blood toward the periphery, but unfortunately the arterial blood soon returns to the body by collateral veins without passing through the capillaries of the limb. The operation is therefore harmful.

The effects of a lateral anastomosis between the main artery and vein of the limb are, as has been indicated, also harmful. Necrosis and gangrene usually rapidly increase after such an operation which even fails as a temporary method of improving the collateral circulation.

TRANSURETHRAL CORRECTION OF PROSTATIC OBSTRUCTION*

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THERE is probably no operation in surgery which has done more to relieve suffering humanity than prostatectomy. The success attained in relieving those suffering from urinary obstruction has caused a large number of men past middle life to sacrifice their prostate gland as a ransom for freedom of urination. In spite of the improvement in surgical technique, the marvelous improvement in the preoperative preparation of patients, the special attention given to decompression through drainage, and the improvement in the various laboratory methods for determining the proper time for operation, this operation with its potentially high mortality and morbidity rate has not fulfilled the ideal. The success of prostatectomy is so generally accepted by the profession that relief by removing, by a minor operation, only that portion of the gland that is causing obstruction until recently has received indifferent attention, except by a few surgeons.

One has only to review the literature to observe the array of splendid devices and procedures that have been advocated for the relief of vesical orifice obstructions, which is sufficient testimony to the eagerness to substitute methods of simplicity for the former orthodox measures with its complications and dangers.

As early as 1830, Guthrie devised an instrument and described his operation for the correction of certain bar obstructions of the vesical neck. Civiale and Mercier later devised instruments and laid claims for the operation. Bottini in 1874 introduced his cautery incisor. Freudenburg in 1897 and Chetwood in 1901 modified the Bottini instrument. The inability to visualize the operative field during the operation resulted in numerous failures and accidents that caused the instrument to fall into disrepute.

Renewed interest was directed to this phase of urology when Young in 1909 presented his punch instrument with a report of excellent results in certain selected cases. As adequate provision for hemostasis was not provided, the extensive removal of tissue was not possible and a warning was given against the use of this instrument in adenomatous hypertrophy.

Caulk in 1919 presented his cautery punch in which the use of the cautery blade to section tissue and reduce hemorrhage permitted the operator to remove more tissue. Undoubtedly he was the first to obtain satisfactory results in other than bars and contractures.

With the advent of the various high frequency currents used in the field of medicine, new impetus was given to this type of operation.

Collings in 1926 reported the sectioning of bars and contractures by means of a high frequency electric current with suitable electrodes through the panendoscope under vision with a lens system. He was insistent that his procedure be limited to bars and contractures of the vesical orifice. The same year, Maximilian Stern presented his ingenious instrument, which he termed the resectoscope, and to him must be given the credit for the invention of an instrument that is superior to its predecessors.

In 1930 Kirwin introduced his resector, using an electrode to coagulate and render the tissue hemostatic prior to its removal by a rotating knife. During the present year, McCarthy has adapted the principle

* From Crowell Clinic of Urology and Dermatology, Charlotte, N. C. Read before the New York Society of the American Urological Association, January 27, 1932.

of Stern, using a cutting loop through a specially constructed panendoscope with which he has had remarkable success in remodeling the prostatic urethra.

Numerous others have made improvements or modifications of the various instruments that have been introduced to the profession; the ones outlined constitute a résumé of the more important contributions.

In 1927 the author began the journey into the wilderness, following in the pathway blazed by Stern, until the trail terminated and it was necessary for progression to hew his own pathway onward to the summit of idealism. The peak has not been attained, but progress has been made.

The operation as presented by Stern was described as being bloodless; this was found to be exaggerated. There was no provision for the control of hemorrhage should the occasion arise. The presence of hemorrhage greatly prolonged the procedure and limited the amount of tissue that it was possible to remove. I have made numerous changes in the original instrument, enlarging the length and depth of the fenestrum, increasing the illumination, perfecting the loops to such a degree that they render adequate service under the most adverse conditions and perfecting an arrangement that permits the sectioning of tissue and rapid hemostasis, that allows the most extensive removal of tissue during one sitting.

Any form of electrical current, direct, alternating or high frequency, when of the proper voltage, amperage and continuity of energy application will give the so-called electrical cutting of tissue. Commercial electric current cannot of course be used in surgery on account of the chemical changes or violent contractile effects produced by the low period of alternation. Therefore high frequency currents are used, which on account of their rapid rate of oscillation of current flow (at a rate of upwards of a million oscillations per second) are without electrochemical action and practically free from neuromuscular responses, even though heavy amperages be used.

The character of the different high frequency surgical currents employed varies immensely and different types of current produce radically different results. Generally speaking, there are two types of high frequency currents, either damped or undamped. An undamped current is one which alternates in direction of flow and substantially uniform rate of amplitude. A damped current is one which varies periodically in rate as well as amplitude. An undamped or continuous wave current flows with practically a continuous application of energy, whereas a highly damped current consists of recurrent bursts of energy or electrical discharges of considerable intensity but of short duration with long periods of inactivity between wave trains.

These two fundamentally different types of high frequency current distinguish basically between the so-called cutting and coagulating currents. Therefore the fact that a current is of high frequency does not necessarily suit it to electrosurgery. A pure, undamped or continuous wave current, although it has excellent cutting qualities, offers practically no advantages over the ordinary cold blade punch operations, as it has very little dehydrating or coagulating effect (with consequent hemostatic properties) on the severed edges of tissue, which is one of the chief factors desired in prostatic resection.

On the other hand, a highly damped current will desiccate or coagulate tissue, but has absolutely no cutting ability. A moderately damped current has the characteristics when applied through the proper electrodes of creating a small, though intense arc at the point of contact between the cutting electrode and tissue; dissolution of the tissues in the immediate path of this arc takes place and they are severed as though actually cut. The electrode severs tissue as readily as the sharpest scalpel, and there is little if any mechanical resistance encountered as the cutting

electrode passes through. Moreover, the intense heat generated at the point of contact dehydrates the severed edges of tissue and they present a thin depth of dehydration (or combined zone of dehydration and coagulation), which seals off the capillaries, lymph ducts, and smaller blood vessels, thereby preventing bleeding and oozing from these sources. The depth of this zone of dehydration depends not on the voltage or power of the cutting current, but on its characteristic or wave form, as previously pointed out.

The Davis-Bovie electrosurgical unit is constructed in two entirely separate sections within one cabinet. The cutting section is constructed to produce a current of moderate damping which has been pointed out as being the ideal current that has the peculiarity of sectioning tissue with a minimum of hemorrhage. The other or coagulating section produces a highly damped current which has no cutting qualities but is ideal for the rapid coagulation which is at times necessary for hemostasis. Each of these sections is an entirely separate electrical circuit with individual controls and adjustments. An electromagnetic selector is provided which instantly connects either current to a common outlet through the operation of the proper treadle of a double foot switch.

The perfection of the instrument and application of suitable electric currents permits the removal of sufficient tissue with adequate hemostasis under vision, permitting the correction of many obstructions that were formerly considered amenable only to complete enucleation of the gland. During the past five years, the writer has operated upon cases of various types of prostatic obstruction with uniformly successful results.

The fundamental principle in this problem is the removal of the obstructing tissue, either by excision or destruction or a combination of these, sufficient to relieve the obstruction with a minimum of injury to the surrounding parts. Equally important is the restriction of complications and the adequate control of hemorrhage. With the present equipment, it is possible to relieve more than 90 per cent of the cases with an operation that is simple, wherein the risk is negligible and the final results are equal if not superior to those obtained by prostatectomy.

All operators are familiar with the marked shrinkage that regularly occurs in the enlarged prostate following the preliminary cystotomy drainage prior to subsequent enucleation in the two stage prostatectomy. Since the prostate diminishes in size with the removal of the residual through a cystotomy incision, the same shrinkage follows the adequate drainage instituted through removal of the tissue that is impinging upon the vesical neck and posterior urethra. When this can be successfully accomplished through transurethral resection, the indications for more radical surgery vanish, for few patients will submit to a prostatectomy when a minor procedure will permit them to void freely and completely empty their bladder.

Regardless of the type of obstruction or the operation that is to be performed, it is of paramount importance to prepare these patients properly by thorough decompression with a retained urethral catheter. A careful watch should be maintained of the nitrogenous constituents of the blood; the renal function should be stabilized and the correction of other constitutional abnormalities should receive appropiate consideration. It is only by adhering to these well-known surgical principles that maximum results with a minimum mortality rate may be obtained.

The cases treated by resection have had the usual complications concomitant with age and obstruction, varying with the age of the patient and the degree and duration of the obstruction. The frequency, difficulty, dribbling, retention, incontinence and the general symptoms of uremia and circulatory embarrassment have been identical with those reported by surgeons who have resorted to enucleation for a cure.

The residual urine in this series of cases has varied from none at all to 48 ounces with complete retention. The amount of residual urine is not a criterion to the amount of obstruction present. In some patients without residual urine, large bilateral and middle adeno-fibromatous hypertrophy was found; in others, with complete retention, only a small bar or median lobe was found to be causing the obstruction.

Table 1

Analyses of Cases Operated upon by Resection

Contracted vesical orifice		21
Median lobe or bar		87
Unilateral lobe		8
Unilateral and median lobe		39
Bilateral lobes		58
Bilateral and median lobes		62
Carcinoma		40
Following previous prostatectomy:		
Perineal	9	
Suprapubic	14	23
Recurrences, median lobe resected 1929		
Lateral lobes resected 1931		1
Total		339

From Table 1 it will be observed that practically every type of obstructing gland has been operated upon by this method. During the past year 158 obstruction cases have been operated upon by resection, while only 12 have been operated upon by prostatectomy.

The amount of tissue that was removed varied from 1.5 gm. in the contractures and small bars to 45 gm. in the larger types of hypertrophy. It is frequently surprising to note the small amount of tissue removed in patients with complete retention and the resulting freedom with which they completely empty their bladders.

Eleven of the patients operated upon during 1927 and 1928 required a second operation within six months, as sufficient tissue was not removed at the initial operation. In 2 of these cases, failure in the equipment before completion of the operation caused a discontinuance until a later date. The other 9 were due to the inability to remove sufficient tissue during the length of anesthesia, with an equipment that was far inferior to that in use at the present time.

Two cases during the present year have required a two-stage resection; one of these was elective, in the other the anesthesia was of insufficient duration to permit the removal of all obstructive tissue.

The average stay in the hospital after operation has been four days; 3 patients remained two weeks; 18 one week, while all others have been dismissed within three to five days.

There has been only one recurrence; a patient in which the median lobe was resected in 1929. The lateral lobes at this time were not enlarged. He returned in October 1931, with complete retention due to large bilateral hypertrophy. The lateral lobes were resected with excellent results.

You will recall that 23 of the cases reported in this series had been subjected to a prostatectomy within five years prior to their admission for resection, in which a definite recurrence was found. Approximately the same number of patients have had a resection as have had a prostatectomy in the same geographical area within the past five years, with a recurrence morbidity of 23 to 1 in favor of resection. I, therefore, think that it is incumbent upon the prostatectomists to prove their logic that the incidence of recurrence will be greater in resection than after prostatectomy.

HEMORRHAGE

One of the chief difficulties with transurethral procedures has been in the proper control of hemorrhage. The current supplied by the Davis-Bovie electrosurgical unit sections tissue with practically no hemorrhage during the operation. The highly damped current also available and the technique to be described should the occasion arise permits of rapid and effective hemostasis. There has been one case of hemorrhage in a patient with a carcinoma that involved the left lateral wall of the bladder which required cystotomy for its

control. The operative site was free from hemorrhage and obstruction.

Two cases of secondary hemorrhage have occurred; one on the tenth day, the other on the fourteenth day. Both of these cases were easily controlled by coagulation through the urethra. Blood clots may be so easily evacuated from the bladder with the author's cystoscope curette and coagulation of the bleeding vessel is so readily accomplished that secondary hemorrhage, if it should arise, is of minor importance.

One accident has occurred; a patient sixty-eight years of age with very large bilateral and middle lobes with a small diverticulum in the posterior bladder wall had a marked bronchiectasis with paroxysms of coughing, with a nervous disposition and continued grunting. During the beginning of the operation with the bladder well filled, a paroxysm of coughing caused an intraperitoneal perforation of the diverticulum. Immediate suprapubic cystotomy and drainage of the peritoneal cavity was induced. Ten days later the prostate was removed suprapubically with uneventful and complete recovery.

INFECTION

As the lymph channels and blood vessels are sealed by the dehydration incident to hemostasis, postoperative infection has been of negligible frequency. The temperature elevation has varied from normal to 104°F. Fifteen per cent of the cases have had some elevation. The fever has not persisted longer than one week in any case. A chill preceded the fever in 18 cases. The temperature elevation has been lower as a rule in those patients that have been on preliminary drainage with a retention catheter and have developed an immunity. Eight cases of epididymitis have occurred, all subsiding without interference.

CARCINOMA

Forty patients have had carcinoma; 4 have died of carcinomatosis without recurrence of the obstruction. One of these lived three years and nine months after the operation. All others are living and free from obstruction.

MORTALITY

There has not been a death immediately following resection. In one patient with a very bad cardiac lesion and very large bilateral and median lobe obstruction, the passage of the examining cystoscope produced excessive hemorrhage. The resectoscope was employed only to control the bleeding. The patient left the hospital in three days, but succumbed to his cardiac condition three weeks later. I do not believe that the instrumentation hastened his demise. Another patient with a coronary sclerosis was dismissed from the hospital in four days after the operation; was up and about feeling fine without urinary symptoms when he suddenly died in an attack of angina pectoris two weeks after the operation. A third patient was dismissed from the hospital in good condition. While at his distant home a slough from the coagulated site caused a complete retention and at his return to the hospital he showed an hemorrhagic nephritis which eventuated in an uremic death three days later and three and one half weeks after the operation.

RESIDUAL URINE

The vast majority completely empty their bladder following the removal of the retention catheter. There has not been a case with over 2 ounces of residual urine at the time of primary dismissal. Upon a return for a recheck examination this residual has been reduced to less than one ounce in every case. After sufficient time has elapsed, shrinkage of the gland has been noted and the residual urine has disappeared.

DISCUSSION

DR. JOSEPH F. MCCARTHY: In discussing Dr. Davis' paper of this evening, it may be of interest to quote the conclusions incorporated in a paper of mine published nineteen years ago, entitled "Preliminary report on cystoscopic

intravesical prostatic intrusion and other obstructing conditions in the region of the vesical sphincter."[1]

"The preceding chapters patently emphasize the very great importance of early diagnosis, years earlier than is at present the rule, diagnosis made before profound structural secondary changes have taken place. When one considers that the average wide-awake practitioner now regards the estimation of the blood pressure of his patient as an integral part of his routine physical examination, does it not seem plausible that a properly conducted campaign of education on the part of urologists would sufficiently stimulate the interest of medical men by directing their attention to the importance of routine inquiry into the condition of the genito-urinary tract, particularly of patients over fifty?

"I would minimize the importance of rectal examination and emphasize the necessity of estimating at a number of sittings the amount of urine remaining after the patient empties his bladder as thoroughly as possible. I would also point out the imperative necessity of early cystoscopic and posterior endoscopic examinations of patients showing any appreciable amount of residual urine, and symptomatically giving evidences of the likelihood of prostatic disturbances. As it is at this time particularly that these patients will, in all likelihood, prove amenable to suitable cystoscopic treatment.

"If heed therefore be accorded the message conveyed in this communication, it may not seem unreasonable to anticipate an earlier and a more effective means of combating this sinister obstacle to many a 'ripe old age.'"

Later in conjunction with Mr. Reinhold Wappler we experimented with a wedge-shaped electrode, and still later with loop electrodes identical with those now in use. As a result of these experiments we came to the conclusion that the electrical and optical equipment of those days were not equal to the exacting demands of so highly technical a procedure as endoscopic revision of the prostatic encumbered urethra.

My interest was again renewed in this fascinating study by the work of Caulk and Davis, together with the impressive case reports emanating from their respective clinics, and at my suggestion Mr. Frederick Wappler undertook the research which resulted in the present cutting and coagulating machine, which adequately meets the exacting requirements set forth by me as necessary prerequisites, before any attempt should be made in the construction of endoscope and cutting loops, designed to carry out the actual operative steps.

In the approach and objective of Dr. Davis and other workers in this field, as I interpret them, there is a wide divergence of opinion from my own, which is as follows:

The rationale of the method is, or at least should be, the removal of as much of the obstructing prostate as in the experience and judgment of the operator seems necessary. This, it seems to me, because of the age and the accompanying disability of the patient, should be carried out in as brief a time as possible.

Time alone will determine the amount of tissue removed. This will always, however, be regulated by individual case requirements. It is our present belief that the lateral lobes play a relatively minor role in urinary obstruction, and that the major role is largely the result of infiltrative or glandular distortions on the floor of the bladder neck and deep urethra, and it is because of the resultant loss of elasticity that the neuromuscular mechanism is not equal to the job of depressing this floor as it is normally done during the act of micturition. For these reasons we cannot subscribe to the opinion expressed that a large cavity simulating that following prostatectomy must result. This observation is likewise confirmed clinically not only by us, but also in the hands of others, notably Engel of Crile's Clinic.

The operative field should be under the most precise and comprehensive visual control.

The cutting loop should have sufficient flexibility to enable the operator to effect a deep incision where the intrusion is most pronounced and the factor of safety greatest and as superficial as desired, in the region of the veru montanum, where it is least.

The cutting loop should be drawn through the prostatic tissue very slowly, taking about twenty seconds for its complete excursion, so that it will coagulate the tissue as it cuts. This coagulation should, however, be as superficial as is consistent with adequate hemostasis.

Upon removal of the wedge-shaped cast, the oozing points are visualized and gently coagulated *under vision*. This coagulation must be localized to the precise bleeding point, to the end that but islets of coagulated tissue remain.

[1] Am. J. Surg., September, 1913.

These small points of coagulation, together with the very superficial coagulated trajectory of the incised area, logically predispose to early urethral convalescense, which is quite different from hospital domicile. By this procedure the rapid epithelization should and does eventuate. The possibility, also, of late secondary hemorrhage as well as fibrous tissue replacement is thereby rendered the more remote.

The question of hemorrhage is at present the high point of controversy, though I here predict it will not remain so for very long.

If the complete arrest of oozing automatically implies extensive, deep-seated or indiscriminate coagulation, it might very well be questioned if the cure is not worse than the complaint. Certainly this method of control carries no appeal to me.

If endourethral prostatic surgical intervention is to leave behind as its terminal step a cooked urethra, we had better rely on prostatectomy.

In our service at the Post-Graduate Hospital, in well over 100 cases treated by my associates and myself there were but 3 cases in which it was necessary to re-introduce the panendoscope, evacuate the clots, visualize and coagulate the bleeding points. These patients convalesced uneventfully.

Quite recently I encountered a case where the prostate was malignant and it was necessary to introduce via the urethra a Ballenger bag. This worked out so successfully that further study has convinced us of the complete feasibility of this procedure. Small bags have been made in our clinic which may readily be introduced through the sheath of the instrument, the latter withdrawn, and the bag then filled with 40 or 50 c.c. of water, and then gently drawn into the prostatic urethra. A variety of types of these bags, with and without accompanying catheter, are under construction at the moment. In our hands these are more a mental solace than an actual need. With our improved technique, their employment will be rare indeed.

My interpretation of the procedure as a whole is that we are dealing with a tubular structure into the lumen of which are projected irregular distortions of pathologic prostate, most of which extends in the long axis of the canal. This calls for the removal of the obstructing tissue in the form of tubular, or preferably wedge-shaped casts. These casts naturally are best removed by a loop-shaped cutting appliance. In effect, these encroachments on the tube which, because of the facility of their removal with this new electrical apparatus may be considered as so much plastic material, would I submit be removed by an artist in a manner somewhat similar to the method as herein advocated.

Certain it is, the fenestrated type of instrument, with its restricted visual field and the necessity of forcing the tissue into this fenestrum as a necessary preliminary to its removal, is neither logical nor practical; and except in the hands of men like Dr. Davis will not enjoy general usage.

This revolutionary procedure with its attendant spectacular successes is big enough and promising enough to merit our philosophical, our dispassionate consideration. We should, insofar as it is humanly possible, submerge individualistic ego; there is glory enough for all concerned. If I have evidenced even a trace of dogmatism in this discussion, it has not been by design. If evaluated (as I trust it will and should be) it will be regarded as an effort to provide a discussion worthy of the brilliant work of Dr. Davis, and the long journey he has made to further acquaint us with his work and that many others of our colleagues have made to see and hear us.

Dr. Thomas J. Kirwin: Dr. Davis has described his method of prostatic resection by the urethral route and we have also heard another method described tonight, both striving for a common result. I shall confine my brief discussion to the mechanical and electrical aspects of each.

No matter what instrument may be employed, work upon the bladder neck requires the utmost operative precision. The Stern instrument possesses certain mechanical features which demand the exercise of considerable skill on the part of the operator. Yet there are advantages available today unknown when the Stern instrument was designed, and these the skilled operator should not overlook.

Of primary importance is the cystoscopic picture obtained. The McCarthy telescope cannot be surpassed for this purpose, and is the basic factor in any method of bladder neck resection. This will have been forcibly impressed on any one who has had opportunity to use both the instruments under discussion. The direct type of telescope with which the Stern

is equipped does not afford so accurate a picture as that obtained with the McCarthy. With the direct-telescope instrument, one sees but a single aspect of the bladder neck; while with the McCarthy, inspection is made from the angle affording the best and most comprehensive view. A number of observers have noted that the direct telescope, on this account, gives a misleading view of collar conditions even in a normal bladder neck.

Visualization of the cutting loop in the McCarthy electrome is complete; motion of the loop is toward the operator, and both ends of the cut are constantly in view under full illumination. The position of the loop in the open-ended sheath permits a freedom of manipulation and an accuracy of application heretofore unobtainable. This, as you all know, is not true in the Stern, as the loop is usually pushed away from the operator and cannot be seen after engaging the tissue.

In regard to the cutting unit: it will be long indeed before the McCarthy apparatus finds its equal in cutting ability and splendid coagulating effect. It is surely another triumph for urology that our specialty has once again given to the world of surgery and medicine a modality of untold importance. Years will probably pass before all the potentialities of the new type of current will be fully appreciated.

All who are interested in vesical neck resection must realize that this unit is a culmination of the efforts of a small group of men who have devoted years of experimentation and research to it. The instrument and the electrical apparatus had to be developed side by side. The benefit of the experience and efforts of these men has been made freely available to us, and we should accord them full appreciation for the vast amount of time, energy, and money they have expended. I wish to take this opportunity of congratulating Dr. McCarthy for placing on a practical and time-saving basis this new method of the treatment of prostatism.

Criticism, to be helpful, must be constructive, not destructive. We should display an intelligent appreciation of what others have done, instead of heaping wholesale condemnation upon their accomplishments, often without sufficient investigation to discover whether or not their methods possess merit. Though we may not all agree as to the value of electroresection, it is most satisfying to see how open-minded the majority of leading urologists are regarding it. Dr. Lowsley does not share my personal enthusiasm, yet he has gladly placed at my disposal all the facilities of his department and is turning over a series of cases for investigation, thereby granting me every opportunity to demonstrate its scientific value.

The entire question as to the employment of electroresection in urologic work is now being freely discussed, and, no matter what our personal prejudices, we should retain the open-minded attitude in regard to it. There is an old aphorism which says: "Give me the radius of a man's tolerance and I will show you the circumference of his intelligence."

Since 1923, I have relieved some 700 patients with prostatic obstruction by transurethral surgery at New York University, Bellevue Hospital, and in private practice. There have been no operative deaths; I have not had to open the bladder suprapubically for bleeding.

From 1923 to 1926 I recommended transurethral surgery for prostatic bars, scars following prostatectomy and obstructing carcinomatous bars. During this period I attempted to relieve benign enlargement of the prostate. Using the tube set, the radiotherm, primary bleeding often interfered with vision. The efficiency of the current only permitted the removal of small sections of the gland, and I felt that whittling away for an hour or two produced too much instrumental trauma. I was able, in most instances, to reduce the residual urine with the knife or loop electrode; but I felt it would be wiser, in benign hypertrophy, to do a prostatectomy.

Shortly after this a spark gap machine, the electrotome, was developed. This unit proved more efficient, but not efficient enough to excise a moderate or large lateral or median lobe obstruction. It was found that the machine would heat up after using it for thirty or forty minutes. "Sputtering" occurred at this point, and the cutting power was diminished. Hence the relief of a typical benign enlargement of the prostate was again precluded.

However, there are certain patients with prostatic obstruction who refuse or are refused prostatectomy. From 1927 to 1931 I operated upon 20 such patients. Nine had refused prostatectomy; in 6 cases the referring doctor requested transurethral surgery; 4 had serious heart lesions, and one diabetes. By cystourethroscopy, this group showed a bar plus slight lateral lobes, intraurethral lobes or

median lobes. Half of these patients had a residuum of 60 to 120 c.c., the remainder 180 c.c. to complete retention. After operation they all emptied their bladders and were relieved of their symptoms save 3, and they retained 7, 10, and 15 c.c. respectively. Of special interest is W.G., aged seventy-one, referred by Dr. Keyes in March of 1927. One month previously, Dr. Keyes had done a litholapaxy. I excised a bar and intraurethral lateral lobes. It is now approximately five years after operation, and the patient empties his bladder without symptoms.

Desiring a more powerful spark gap cutting current, I suggested my requirements to the High Tension Corporation during the College of Surgeons Congress in Philadelphia in 1930. Since then their engineers have developed a supercutting current which not only cuts through tissue quickly and easily, but coagulates at the same time. The character of the current allows this very necessary factor to take place. In the spark gap machine, there is a time period between the high frequency oscillation cycles. Coagulation takes place during this pause.

In the tube type machine the high frequency oscillations are continuous, with no pause between the cycles; hence the coagulation is not very efficient, and important bleeding sometimes follows:

I have been using the high tension apparatus for the past several months with entire satisfaction. I have been able to excise as little or as much of the prostate gland as desired. One can almost say, "What used to take hours, can now be done in minutes." Here again I have had no important primary or secondary bleeding. The cutting apparatus is so powerful that I have not had the courage to open up the "throttle" beyond half speed. I employ Reinhold Wappler's No. 28 French bakelite sheath (to prevent short circuits) and a rather large loop electrode bent at a right angle with the long axis of the electrode. To complete the outfit, the author's cystourethroscope telescope, or panendoscope telescope, fit perfectly in the bakelite sheath.

I have been extremely pleased with my results thus far. The patients have been relieved of a serious lesion without surgical shock, and without the one complication that brings disrepute to transurethral surgery, namely, hemorrhage.

Dr. Alexander Randall: I have not had the privilege of seeing Dr. Davis operate; but I have been asked to discuss his work before. Looking back on it, I realize that I was sensibly anxious as to its value, and always kept before me one idea, i.e., are we in performing a prostatectomy doing more than is necessary? And is the time coming when partial removal of obstructing tissue will be found to be all that is required?

Tonight I have heard no mention made of two phases of this subject. One is why a patient with hypertrophy has residual urine. I think Dr. McCarthy has created a new point of view in speaking of the advantages of canalization of the prostatic urethra. Probably the essentially correct viewpoint to take of prostatic obstruction is not so much one of the existence of obstructing hypertrophied tissue, as of the prostatic capsular tension. And if by canalization the relief of tension is obtained, I am of the opinion that in a proportion of cases relief of residual urine will also follow. The question in my mind (which of course must await the judgment of time) is whether or not one can obtain a permanent result by this method.

But there again we have a second point: Is it not perhaps better to subject an elderly man to two minor procedures than to do more than is necessary?

I have heard exaggerated views on this question of hemorrhage. I do not quite know why others fear it so. I grew up in my early urological life in close association with Young's punch and I became, and I am afraid I still am, rather callous to hemorrhage. Granting that it can be of serious moment, on the other hand think how often we paid little or no attention to what might be called serious bleeding following the punch operation. I rather feel that it is neither the whole story, nor a matter of deep concern, nor impossible of control by mechanical means.

I am in sympathy with Dr. McCarthy's remarks as to the inadvisability of the unskilled operator using this method. One cannot expect this instrument, or that, to work like a graphophone, i.e., just by putting a needle in place, turning a switch, and so making a surgeon of anyone who has the money to buy the type of apparatus. My experience with various machines of this type has convinced me that they can all be made to do the work. But it is not easy work; it is highly technical.

This brings up another point not mentioned this evening, the matter of some standard of guidance as to when the operation is finished. I noticed that the title of Dr. Davis' paper was not "prostatectomy," but "relief of prostatic obstruction." I am convinced that prostatectomies will never be done by instrumental methods. But again I return to the original point: When will we be able to say it is not necessary to do gross surgery, and when will we learn the limits to which we must go to relieve a patient?

The happiest point of the evening is the look into the future that it gives us. I see in this method the complete obsolescence of the punch operation. Tonight it is ended! And I see in the future another factor, referred to by Dr. McCarthy, the early handling of prostatic obstruction, the control of what we might call the "preprostatic" and the preservation of normally functioning organs, rather than the correction of obstruction after gross destructive conditions have developed. When we can do that, we will be preventing that sequence of events we are all familiar with, the destruction of the bladder's muscular function, the development of diverticula, the effects of back pressure conditions on the kidney, cardiac damage, high blood pressure, etc.

In other words, I think we can begin to see that in the future we can take a number of patients to the operating room before damage is done. And we may even enter that Utopia of Medicine where we can apply ourselves to preventive surgery.

Dr. Oswald S. Lowsley: The urologists gathered here always welcome any promising new instrument, or any new series of instruments, or instrumental methods, because the only difference between a good urologist and a good general surgeon is that the modern urologist is a good general surgeon who has instruments of precision and knows how to use them.

It seems to me that the most outstanding work of the last decade is this work. It overshadows uroselectan, which was rated (and should be) as a real contribution to urology.

One thing is certain, that the type of operation described by Dr. Davis this evening has quite properly ended the punch operation. Though there has been a time in this city when punch operations were not nearly sufficient in numbers. The Young punch was the only instrument we had at one time. There were accidents; there will be with every type of instrument. Dr. McCarthy has been honest enough to admit a death. There have already been many with this new type of procedure. I know of one in Brooklyn, and two out West. But the fact that there has been an occasional death does not give the method a black eye. A clinic such as ours cannot afford to dismiss an idea like this without trial. All of the members of my staff are young. We cannot allow their minds to crystallize. Therefore I have given Dr. Kirwin a free rein to his enthusiasm. He will do a series using this new method.

While I grant that it requires skill, this is not a trick operation. Both Drs. Davis and McCarthy would be the last to say that it is to be restricted to only a small group of experienced men. It can be done successfully by those with a moderate ability. I know, because I have done it several times myself.

I cannot help but feel that canalizing a prostate with a large adenoma is a decided mistake. I hate to put any fly in the ointment; but that is my firm opinion, and has been from the beginning. If that belief is wrong, I am willing to be shown, and to admit I am wrong. But this procedure seems to me to be in the same class with the old Sleuter method of tonsillectomy. If these patients live long enough with a considerable portion of the prostate left in, they will return for prostatic removal, or another operation of the sort. This may be desirable; but at present I do not think so. After the enthusiasm of the pioneer has subsided, somehow I feel that although there will be far larger numbers of patients operated upon by this new technique, they will not be the fullblown adenomatous prostatics, but the borderline cases. Dr. Randall seems to have put it very nicely by saying that preventive medicine may enter at this point.

I am under the impression that our present criterion for removal of the prostate by this or any other method should be residual urine. Just because a prostate is enlarged does not necessarily mean it should be removed. Many a patient suffering from adenomatous hypertrophy of the prostate has been carried along for years by palliative treatment, without operative intervention. It has been so in the past; it will be so in the future.

The greatest tribute is due Dr. Davis personally for the persistence he has shown against

great vitriolic criticism on several occasions, and for putting this method over in spite of it. When he can show only 3 deaths in 339 cases, his method merits one's favorable consideration.

DR. THOMAS C. STELLWAGEN: (Philadelphia) With frankness I confess that I came over from Philadelphia somewhat in doubt, but I am equally honest in saying that conversion to transurethral removal of the obstructing portion of the prostate gland, in selected cases, offers an apparent solution to a very hazardous operation. It is entirely probable that the operation of prostatic resection per urethra will have to pass through a formative stage. In my opinion the work of Dr. Davis and Dr. McCarthy has done much to shorten this formative stage. Most men after 50 are concerned about their prostates, and some of them undoubtedly would be greatly relieved by the procedures that Drs. Davis and McCarthy so ably demonstrated.

There is no question that prostatectomy is passing through the stage of understanding and development that appendectomy travelled during its introduction to the profession and the public at large. Many of us can remember the acrimonious disputes that were engendered between the two schools of belief in regard to the question as to when the appendix should be removed. This has largely, at the present time, been evaluated. When the patient has appendicitis, the appendix is taken out. Of course there are exceptions, but the old disagreements are a matter of the past. Education of both the general practitioner and the public is rapidly changing the present day status of the prostatic case. The urologist still has to contend with procrastination on the part of both the physician and the patient; but we all look forward to the day when the prostatic will be referred to the specialist before he has become seriously crippled by his disease.

The work that Dr. Davis has done, and the perfection of the procedure by Dr. McCarthy and Mr. Wappler, to my mind, will succeed in removing much of the sting of danger from early prostatectomy. To me the question resolves itself into the problem as to the type of case which is approachable by means of intraurethral resection. Malignancies and obstructions of the prostate that are not too large will be far better handled by this method than by any other surgical procedure. The frail old man who could not stand a suprapubic or perineal prostatectomy can often be given relief for the remainder of his life by this method.

The question has arisen concerning the danger of hemorrhage. Of course it is a vital problem, but I cannot see that it is of such magnitude, even though it does occur; which fortunately does not often happen. It does not seem to me so much of a risk; for after all, it does not entail very serious shock to open the bladder subsequent to intraurethral resection and control the hemorrhage. This problem of hemorrhage control is largely eliminated by the coagulation powers of the current. Dr. McCarthy is at present working upon a device that I feel will give him the whip-hand over postoperative bleeding.

Another question that some critics have put forth is the necessity for re-resection in some cases. This again I do not see is of any great moment, since from what I have learned it will not entail any very great danger to life, and is a much less serious problem than removal of the gland by the old method.

DR. WILLIAM M. SPITZER (Denver): While I have not had a great deal of experience in this new field, I have resected a few cases. Most of them have been bars, the broad bar described by Dr. Randall which is a matter of inflammation, as well as the narrow bar. In those cases I have met success; but where I have attempted to go further afield and attack a large prostate, I have gotten into trouble and had to open up suprapubically, in 2 cases, for hemorrhage. This was probably due to lack of proper technique, or to lack of the proper current. Considering my experience with the current I have had to use (which was not the Liebel-Flarsheim or the Wappler machine), I think we may go into this field cautiously and carefully using this newer equipment, with much hope. The skill which has been so strongly emphasized is not so much a prerequisite as a thorough knowledge of the bladder neck, its physiology and anatomy, and the ability to interpret what we see. A certain amount of technique is, of course, necessary. But I presume we all have that. Time alone will tell whether this will be the method of choice in dealing with adenoma of the prostate.

In the larger prostates it is hard to say whether we are dealing with a true tumor or an inflammatory condition. If inflammatory, as mentioned before tonight, drainage of the

bladder itself helps to cure it. Therefore perhaps drainage of the bladder per urethra may not suffice.

None of us fears hemorrhage with an open bladder. But once gross hematuria caused by removal of an obstruction at the bladder neck, transurethrally, sets in, a vicious circle is started. First comes the desire to urinate, and with that a whole chain of symptoms. More bleeding is caused by the efforts of the patient to empty his bladder. The attempt to empty causes more bleeding; and unless we can pump out the clots, and stop the bleeding by going in again, we are in deep trouble. Along this same line, I believe we have another problem. We are all moving away from catheter drainage, moving on to drainage of the bladder from above, because catheter drainage does not offer immunity against infection; but opening up from above does obviate such infection, the most frequent cause of death. This furnishes food for thought.

In short, this whole problem is all in the future. Many men will work on it. And the consummation of an ideal method will be arrived at only by our joint experiences and our combined failures and successes.

Dr. A. Hyman: I have been interested in this subject for a number of years; in fact, since Dr. Beer introduced the fulguration treatment of bladder tumors. In 1914 we reported a few cases at the Academy of Medicine, in which we had destroyed median lobes by a fulguration method similar to that described by Dr. McCarthy, with fair results. Later on our results were less uniform; and because of the poor endotherm apparatus at our disposal at that time, we became discouraged and dropped the procedure for a while.

A few years ago I had an opportunity to see Dr. Luys of Paris do his forage of the prostate. He demonstrated a number of patients with prostatic hypertrophy who had been foraged with excellent results. I was not, however, impressed by his method. It was crude, cumbersome, slow and painful. But I had an open mind on the subject, and felt that there was a future in this method provided the proper endotherm apparatus was devised. Therefore when Dr. Davis reported his wonderful results with the modified Stern resectoscope, and Dr. McCarthy followed with his new apparatus, it seemed the time had arrived for further trials of the procedure.

I accordingly spent a few afternoons with Dr. McCarthy at the Post-Graduate Hospital, and was greatly impressed by his technique and his results. Although my experience is not nearly as extensive as that of either Dr. Davis or Dr. McCarthy, I would like to tell you my impressions.

To date we have used this method on about 15 cases of prostatic obstruction of all types, including median bars and median and lateral lobe enlargements. At first I hesitated to resect the larger glands, confining the method to median lobe enlargements with very gratifying results. We then selected cases with lateral lobe enlargements. I must say that I am greatly impressed with the results so far obtained. There have been complications in 4 instances; a secondary hemorrhage which was readily controlled by coagulating the bleeding points through the cystoscope, a rather acute pyelonephritis lasting a few weeks, and epididymitis in 2 instances. To avoid the latter complication it will probably be advisable to do a preliminary vas ligation.

It seems to me that this new method has an excellent future, although I question whether it will entirely supplant prostatectomy. It will be a matter of a few years before its status can be definitely determined. Undoubtedly as the method becomes more and more popular and in more general use, unpleasant complications will be reported; which, however, should not discourage its use. Despite the opinion expressed by a few this evening, it is a highly technical procedure requiring cystoscopic experience, and is not to be entrusted to the tyro. The potential dangers seem to be perforation of the trigonal region, secondary hemorrhages, and cutting too far forwards, i.e., anterior to the colliculus, with resulting incontinence.

The important point in the whole procedure is the correct interpretation of the obstructive lesion, and to know just how much prostate to resect; and this is not as simple as it sounds. Some patients with enlargements of both median and lateral lobes have been relieved of their symptoms by resecting only the median lobe; others have not, and have required resection of the lateral lobes. At present, it is not often possible to decide just what part of the prostate is responsible for the obstructing factor. As a result of further work with transurethral resection, we may in time determine this point. I am convinced, after seeing the

motion pictures this evening, that I have not removed enough tissue, evidently being too conservative. As a result I have had failures in 3 or 4 instances. In one case we congratulated ourselves on an excellent result. Two weeks later retention developed. In 2 other cases, there was recurrence of residual urine. I think the most important question, after the necessary experience is obtained, is to determine just how much prostate it is necessary to resect, to obtain a satisfactory result.

Dr. W. J. Engel (Cleveland): I have visited Dr. Davis' clinic at Charlotte, and know that he does the work he claims, and does it well. My own experience with transurethral prostatic resection covers a period of about two and one-half years. We started out with the Caulk cautery punch. Our results were very satisfactory with it, and it kept us interested in the work. From this we progressed to the resectoscope as modified by Dr. Davis. I am sure that if we had the mechanical and electrical genius of Dr. Davis, we would have been able to iron out the difficulties we encountered with this instrument. As it was, we pushed on to the McCarthy instrument, and found it superior in our hands. With these three instruments we have treated about 80 cases, and the results have been uniformly good. Fifty per cent of the patients had complete retention, the rest had large quantities of residual urine. In almost every instance they were restored to urinary comfort, with a minimum residuum.

It has been our feeling that the middle lobe is the chief factor causing obstruction. In many cases resecting the middle lobe alone restored urinary comfort, with freedom from residual urine. Subsequent cystoscopy after six or eight months has shown lateral lobe enlargement was still present, even though the patient was able to void comfortably and carried no residual urine. Whether or not lateral lobes constitute a minimum factor in obstruction, only time will tell. It seems to us to be the case.

This new procedure seems ideal in carcinoma of the prostate. We first resect the obstructing portion, giving the patient a good channel to void through, then give him deep *x*-ray therapy. The immediate results have been very gratifying, though of course a longer period of observation will be necessary. The longest case we have treated in this way has gone one and one-half years in comfort. There will doubtless be recurrences, and we will again have to remove more tissue from the bladder neck to permit them to void. We feel that this is much better than the radical operation.

With this method the average hospital stay has been eight days in our group of cases. Convalescence is very comfortable and postoperative reaction slight. In short, we have quite a different picture following prostatic resection from that after prostatectomy. In most instances they are able to void immediately after removal of the catheter, in thirty-six to forty-eight hours. We have encountered some cases in which the final result has been delayed from two to four weeks, after which the patients void comfortably.

Our experience is not unique. In a communication from Dr. Alcock of Iowa City, I find he has treated to this date 96 cases, and is very enthusiastic. We are doing fewer prostatectomies, though there is still a group of cases where this is the procedure of choice. Each case must be individualized. Dr. Lower shares my enthusiasm for this new method and we feel it gives the same relief with a minimum of danger.

Dr. J. J. Valentine: The Department of Hospitals of New York City has been most cooperative with our Urological Service at the Morrisania City Hospital. We have only recently been equipped with a McCarthy surgical unit and our experience with endoscopic prostatic revision is therefore limited to a few cases.

You have been given the history of the scientific advance made in bladder neck work. Personally, I have used all forms of endovesical resection, and like Dr. Hyman recall the work done years ago by Luys with his "forage de la prostate."

Perhaps because of having been one of the earliest enthusiasts of the McCarthy panendoscope, manipulations through it seem logical and practical. My experience with the original Stern resectoscope was very limited, and failures with it when it was first presented naturally should be attributed to our not having had the proper cutting and coagulating current at our disposal.

We have used the McCarthy surgical unit with his special panendoscope in 14 cases to date, classified as follows:

	Number of Cases
Middle and lateral lobes, benign hypertrophies	5
Carcinoma of prostate	2
Contractures of vesical neck following prostatectomy, i.e., scar formation, bands, persistent suprapubic sinuses, etc	3
Fibrous prostate	1
Median bar obstruction	1
Sclerosis of vesical neck (with existing diverticula)	2

Our results thus far have been very satisfactory. The technique should be relatively simple in competent hands. The McCarthy surgical unit certainly cuts easily and coagulates efficiently.

In one case, excessive bleeding occurred and was not controlled at the time of resection. This happened while making a test with a machine that was presumed to cut and coagulate efficiently. It was my desire to give it a fair trial. This machine cut out small pieces of prostate, but they appeared charred, and for some reason coagulation did not check the bleeding. Indwelling catheter likewise failed to arrest bleeding by pressure, and a cystotomy was performed a few hours later. The bleeding was arrested and in due time we intentionally allowed the suprapubic wound to close. The patient still had obstruction, and he was again resected, this time with the McCarthy unit. Several large bits of prostate were removed, and no bleeding followed.

Residual urine has been materially reduced in all of our cases. Some have had no residual since the local reaction from the operation subsided; others have a varying amount from a few cubic centimeters to ½ ounce.

The symptoms of discomfort and burning on urination after the catheter is removed seem to be temporary. We have noted these symptoms to last from seven to ten days.

We have had one death, a negro about sixty-eight years old, with a very large prostate and complete retention. Despite slowly decompressing him for about three weeks and favorable blood chemistry and renal function reported, his general appearance was poor, and ten days after resection he became uremic and died. Autopsy revealed bilateral acute and chronic diffuse suppurative nephritis. Perhaps it was an error to have resected in this patient, although with the findings at autopsy, there is doubt that he would have tolerated any surgical procedure.

It is too early for us to come to definite conclusions about this new method. There is no question as to its efficiency, whether done by the Davis or McCarthy method. The reason the McCarthy method appeals to me more is that I feel thoroughly at home with the panendoscope. In this instrument, the lumen is so much larger and broader and permits looking directly ahead, that if offers perhaps an opportunity to remove larger pieces than through the Davis instrument. The matter of time with the McCarthy technique is negligible; for after the patient has received a caudal or spinal injection, the excision and coagulation takes but a few moments in the average case.

I would like to join Dr. Stellwagen and others who have cautioned those who make light of the technique of this procedure. I do not think it is quite as simple as it may seem; but it will be, in the hands of those who have delicate tactile sense and have had sufficient practice to learn the landmarks thoroughly.

Dr. W. Calhoun Stirling (Washington, D. C.): I think the bugbear of hemorrhage and recurrence of the obstruction has been overemphasized by the critics of this new method. As Dr. Davis pointed out in his paper this evening, it is a simple matter to go in a second time if necessary, a few months or even years later, and resect any remaining obstruction with no added risk to the patient.

Considering the large number of cases reported by Doctors Davis, McCarthy, Caulk and others, I hesitate to report my modest series of 25, all done by the McCarthy techinque. Most of these cases were in men with large lateral lobes, 5 of whom had acute retention. In all cases we were able to make a gutter through the obstruction and restore micturition. Recovery was complete in all cases, with very little hemorrhage except in the first few cases.

I was much impressed with Dr. McCarthy's technique today, and the excellent work he does. With the new machine made by Wappler the fulgurating current affords good control of hemorrhage. In fact, it seems to me that as time goes on we will do fewer and fewer prostatectomies, and more resections, with its lessened morbidity and lowered mortality in expert hands.

Dr. T. M. Davis (*Concluding*): I do not think there need be any argument as to which instrument is superior to the others for this procedure. I am sure that our instruments are not at present the ideal of perfection. I agree that in the McCarthy instrument the vision is broader

than in the Stern resectoscope, the light in front of the lens, and you also have some right-angled vision. Personally, I am more acquainted with the direct vision telescope, and can orient with it better. The McCarthy resector is a nice instrument. I think it has a few defects, as I know the Stern resectoscope has; and they are faults which I have not been able to overcome.

I feel that the future of prostatic surgery lies in the prevention of hypertrophied prostates rather than in waiting until the patient has one foot in the grave and the other on a banana peel before attempting to do anything for him. It should not be a matter of locking the stable door after the horse is stolen. It is up to the urologist to educate the medical man to recognize these conditions early. In the median bars and the small hypertrophic glands, this process is not much more severe on the patient than a complete cystoscopic examination, and causes but little discomfort in the larger hypertrophies.

I agree with Dr. McCarthy that excessive coagulation is not necessary. I do not use the spark gap coagulating current longer than a fraction of a second to a vessel, except where we cannot find that vessel and we traverse the area rapidly with the current imposed on the loop.

As far as secondary hemorrhage is concerned, I have no fear of it whatever. The 2 cases I have had to handle required only five minutes after the patient received the caudal anesthesia until the bladder had been cleaned of clots and the vessel was coagulated. I was glad to have these 2 cases, to show how easy it was.

I think this change in procedure will accomplish one thing not controlled in the past. The operator on prostatic cases has often been the general surgeon. With this resection method that the urologist can offer, general surgeons will lose their prostatic cases, and the urologist will get first choice on deciding what shall be done. He will determine whether or not resection is indicated. In short, the prostatic cases will be returned to the specialist.

I do not see the comparison between tonsillectomy and prostatic resection. I do not think anyone ever dies from dysphagia following tonsillectomy. We do not remove adenomatous prostates for infection, but only for obstruction. Large adenomas should have prostatectomy; I mean the tremendous glands where it is difficult to do any form of instrumentation with any degree of certainty as to what you are doing. But I believe these are the only cases which really have an adenoma. No other gland of the body develops adenoma with anything like the frequency credited to the prostate. I believe about 10 per cent of them are adenomas, and possible 12 to 15 per cent carcinomas. The hypertrophic glands will shrink after operation, and often remain permanently cured.

Someone has said that the only indication for prostatectomy is residual urine. In this I do not agree. I see cases of hypertrophy where there is bladder intrusion yet they can frequently empty their bladder through the prostatic obstruction. In other words, they have only an obstruction, a very few having small diverticula. I think that instead of waiting until obstruction produces residual, the thing to do is to remove the obstruction and stop the getting up at night to void, and so give the patient relief. One case I saw recently has no residual urine, yet he voids every fifteen minutes. He had a prostate so large that we could not do a resection. That is a case for prostatectomy.

We should be just as careful in preparing the patient for this procedure as for any other. In some cases suprapubic cystotomy may be necessary later. If we have to reoperate with a high non-protein nitrogen the patient is a poor operative risk.

As to the time element: this is governed by the amount of obstruction and the amount of tissue to be removed. Four or five years ago we spent three hours whittling away at these larger prostate glands. Now a median bar operation can be done in ten minutes. I have removed a large bilateral adenoma, removing 30 or 40 gm. of tissue, in one and one half hours. Where we find large arteries, of course, it takes longer. The sections of tissue taken out by my procedure with a No. 26 F. sheath are approximately the same in size as those removed by Dr. McCarthy with his loop and a No. 28 F. sheath. In fact, I believe that a larger section is removed with the instruments I use and a No. 28 F. sheath than with the McCarthy resector. In the lateral lobe cases it is possible to remove larger sections because they do not give way from you, and the instrument can get a better bite into the gland.

ELLIOTT TREATMENT OF PELVIC INFLAMMATIONS*

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THE treatment of pelvic inflammations is often prolonged and inefficient. Heat has been used for centuries, but never in so satisfactory a way as that devised by Dr. Charles Robert Elliott.

A thin, distensible, gum rubber bag is inserted in the vagina. Through this a constant circulation of hot water is maintained by an electric pressure pump on one side and a suction pump on the other. The temperature of the water in the machine is regulated by a thermostat and should not exceed 130°F. at the conclusion of the usual one hour treatment.

Holden[1] has shown that this will produce a temperature of 106°F. in the peritoneal cavity and rectum, and 104°F. in the bladder.

A pressure of from one to 4 lbs. is produced in the bag by the use of regulating valves on the inlet and outlet tubes. This distends the vagina, obliterating its rugae, and greatly increases the area available for heat radiation. A treatment is usually given daily. The number may vary from five to twenty. A fair average would be ten treatments.

What are the physiological effects of these treatments?

1. The production of a marked hyperemia in the pelvis.

2. An average increase of 17 per cent in the leucocyte count of 87 per cent of the patients treated.[1]

3. A local elevation of temperature in the vagina, uterus, rectum, bladder and pelvic peritoneal cavity of from 5° to 7°F.

4. The production of a profuse discharge from the cervix and vagina.

[1] Holden, F. C., and Gurnee, W. S. A new method of applying vaginal heat. *Am. J. Obst. & Gynec.*, 22: 87, July, 1931.

When these physiological changes are produced in inflammations of the pelvis, they cause:

1. A prompt subsidence of congestion and inflammation.

2. A resorption of exudate.

3. A definite destruction of bacteria.

4. An out-pouring of mucus and washing away of infective organisms from the cervix and vagina.

There are undoubtedly other effects that are less clearly defined and understood. From a clinical standpoint, we can say that inflammatory masses melt away; pain and tenderness disappear and a foul, purulent discharge from an angry red cervix and vagina is replaced by clear mucus coming from a normal cervix or one showing translucent clear cysts deep in its structure.

Best of all is the fact that a process that formerly consumed weeks of time may now be consummated in as many days and a much higher percentage of the patients treated show a splendid final result.

In 150 consecutive cases of acute salpingitis, chronic salpingitis, pelvic cellulitis and pelvic abscess, Holden[1] lists 81 per cent at the conclusion of treatment under the classifications of: "No pathology, marked improvement, or considerable improvement."

Another startling fact seems to be the marked decrease in the number of operations necessary in these cases. Miss Mackin, the technician at the Jersey City Hospital, states that in her series of 125 patients receiving Elliott treatments, only 8 were operated upon.

The average number of days spent in the hospital is diminished, also, with a

* Read before the Alumni Association of the Ex-Internes of the Methodist Hospital, Brooklyn, N. Y., February 25, 1932.

consequent reduction in expense to the patient.

If patients and physicians can be educated to early treatment of pelvic inflammations, the period of hospitalization will, doubtless, be still further lessened and complete restoration to normal more often obtained.

In what types of disease is this treatment indicated?

1. Acute salpingitis.
2. Chronic salpingitis.
3. Pelvic cellulitis (frozen pelvis).
4. Post-partum and post-abortal parametritis.
5. Pelvic abscess (before and after operation). When used preparatory to operation, an amazing resolution will often take place and the operation may be unnecessary. After cul-de-sac drainage resorption of the exudate rapidly takes place.
6. Pelvic peritonitis.
7. Gonorrheal vaginitis or endocervicitis. The gonococcus is very sensitive to heat and is easily killed. Gonorrhea seems to yield promptly to the Elliott treatment.
8. Dysmenorrhea. "Daily treatments for five days preceding menstruation for three or four months" (Holden). The mode of action is unknown. It has worked in a few cases.
9. Cystitis. Tenesmus and pain rapidly subside.
10. Proctitis. Same as cystitis.

There seem to be no definite contraindications, but certain precautions are necessary. The bladder and rectum should be empty before treatment is commenced.

The first treatment should be limited to one-half hour, and the distention and the temperature should remain low to inspire confidence in the patient. Succeeding treatments take one hour. The temperature starts at 115° and is slowly raised. It should not exceed 130°.

The bag should be well distended but the treatment should be painless. The amount of pressure may be determined the first time by inserting the finger into the vagina alongside the bag. At subsequent treatments, the same pressure, as indicated on the meter, can be used.

The inlet and outlet tubes from the bag should not be allowed to drag on the perineum. This is most sensitive and easily burned. A rolled-up blanket under the flexed knees will hold the tubes up nicely. The tubes should also be surrounded by a piece of gauze to prevent contact with the sides of the introitus.

After each treatment a speculum is gently inserted; the secretion is wiped away from the vagina and the cervix, vault and walls of the vagina inspected. If there is any tendency for a slough to form, the treatments are continued, but the temperature and pressure are lowered. All treatments are discontinued during menstruation.

Our interest and enthusiasm for this method of treatment were stimulated by the first case in which we used it:

E. C., a woman twenty-seven years old, was sent into the First Surgical Service of the Methodist Hospital by Dr. G. H. Davis. She had one child three years old and had been suffering from menorrhagia and a foul-smelling yellow leucorrhea, for two years. She had a progressively increasing constipation and pain in the lower abdomen on defecation. Vaginal examination showed a transverse mass in the cul-de-sac about 2 by 3 inches in size and stony hard, like a carcinoma. A proctoscopic examination showed an extra-rectal mass about 4 inches from the anus which projected into the rectum so much that the tube could not be passed around the projection. The rectal mucosa was normal.

The patient was thin and emaciated and gave a history of a previous tuberculosis of the lungs. A tuberculous tube was considered.

An Elliott treatment of one hour's duration with a temperature of 128°–130° was given. This was followed by a profuse flow of blood from the uterus. Treatments were discontinued for a week. An examination then showed that the mass was only half its original size. Three more treatments were then given, with complete disappearance of the mass. When seen February 12, 1932, the patient had gained 13 lbs. in weight and was in good health. There was no mass in the pelvis. A slight thickening of the uterosacral ligaments could be felt.

The interest created by this first case inspired us to visit Dr. Cosgrove at the Margaret Hague Memorial Hospital in Jersey City. He told us of 20 cases of post-partum infection that had been treated by the Elliott method, with good results. Two cases of cystitis received relief, and one patient with Trichomonas vaginalis vaginitis obtained almost immediate relief. A block away we found an Elliott treatment room in the Jersey City Hospital; Dr. Kelly is supervising this. Some are hospital patients, but many of the patients there are receiving ambulatory treatment. The results are not so promptly obtained in this way, but seem to be very satisfactory in properly selected cases. Better appetite; better sleep and gain in weight accompany lessened pelvic pathology.

I wish there was space in this paper to include the detailed report of these cases kindly sent to me by Miss Mackin. They include acute salpingitis, pelvic abscess, chronic pelvic inflammations, post-abortal parametritis, post-partum parametritis and cystitis.

Two very interesting cases are cited where patients with bilateral salpingitis with palpable masses have become pregnant after receiving ten and twelve treatments respectively.

We next visited Bellevue Hospital and spent a very interesting morning with Doctor Holden. After more than two years of experience with a large number of individuals, we found him still enthusiastic. Two patients were receiving treatment as we visited the room. One had an acute gonorrheal vaginitis.

A letter to Dr. George Gellhorn, President of the American Gynecological Association, brought the following response:

I am glad to say that I have used the Elliott machine for the past year and am very much pleased with the results. Although I have a good many patients who receive the treatment at the office, I believe that its greatest value would be found in hospital work, where patients can be kept at rest.

Let me cite a few of the cases that have been treated at the Methodist Hospital by a number of different men.

F. C., aged thirty-one years. Dr. G. H. Davis.

Complaint: Pain in the right side, dysmenorrhea, and dyspareunia. Had a resection of the right tube and ovary in May, 1922. Entered the Methodist Hospital on January 27, 1932. Vaginal examination showed a fixed retroversion and an inflammatory mass the size of an egg in the right vaginal fornix.

She was given eight Elliott treatments. The mass entirely disappeared and the uterus could be brought forward into normal position, but dropped back again, when unsupported.

An operation for the retroversion at a later date has been advised.

M. C., aged forty-three. Service of Dr. Seymour Clark. Was in the Methodist Hospital from January 24, 1931 to February 14, 1931, suffering from a pelvic abscess. A posterior colpotomy was performed. She remained in bed at home for six weeks after leaving the hospital.

In September, 1931, she began to experience menstrual irregularity and, late in November, had a marked flow followed by a foul vaginal discharge with indefinite pain in the lower abdomen.

Vaginal examination showed a hard, tender mass the size of a lemon situated in the cul-de-sac. There was no fluctuation.

Four Elliott treatments were given. Nine days after admission there was a purulent discharge from the vagina. Seven more treatments were given and she was discharged from the hospital, twenty-two days after admission. The sedimentation time changed from thirteen minutes to four hours during this interval. An examination made by Dr. Clark about a month after discharge from the hospital showed a pelvis free from pathology.

H. O., aged twenty-three. Had suffered pain in the lower left quadrant for one month and a purulent vaginal discharge for four or five years. Admitted to First Surgical Service of the Methodist Hospital January 14, 1932.

Vaginal examination showed a pelvis filled with a hard immovable mass (frozen pelvis). Under nineteen Elliott treatments, the uterus became freely movable and the entire mass disappeared with the exception of a small rounded non-sensitive left tube. The patient insisted on leaving the hospital as she was free

from pain, had no vaginal discharge and felt perfectly well.

O. C., aged twenty years, admitted January 7, 1932 to the First Surgical Service of the Methodist Hospital. Had suffered from a purulent vaginal discharge with pain in the lower abdomen for three years, following a miscarriage.

Vaginal examination showed marked tenderness in the fornices, a badly eroded cervix and an angry red vagina, with profuse, foul, dirty vaginal discharge.

Eleven Elliott treatments were given. The pus entirely disappeared and was replaced by a clear mucus visible in the cervix. The pelvic pain and tenderness cleared up and the erosion of the cervix diminished rapidly in area. Electric cauterization of the cervix was performed to clear up the cystic condition.

M. G., aged twenty years, admitted to the First Surgical Service on November 23, 1931, with a retroversion and acute pelvic inflammatory disease.

One Elliott treatment was given. The operator was inexperienced and maintained the pressure at 4 lbs. for one hour in spite of the patient's complaint of pain. A slough about one inch in diameter occurred in the vault of the vagina. This was well healed in ten days.

A. J., aged twenty-seven years, was admitted to the First Surgical Service of the Methodist Hospital on December 1, 1931, with a Bartholin's abscess and acute gonorrhea.

She was three months pregnant. The Bartholin's abscess was opened. Cervical smears showed the gonococcus.

Twelve Elliott treatments were given. All discharge ceased and the cervical smears remained negative even after a provocative silver nitrate application.

There was no interference with the pregnancy. Discharged recovered on January 7, 1932.

The question may be raised: Have you not chosen your best cases to present?

In reply, I may say that our records show almost uniform improvement in every case of pelvic inflammatory disease that has been thus treated.

This treatment is not entirely confined to the female, for a prostatic bag for insertion in the rectum offers great possibilities in cystitis and prostatitis and even peritonitis in the male. The pressure in this bag should not exceed 2 pounds.

In conclusion, let me again quote the remarks of Dr. George Gellhorn.[1]

> This . . . will help to cure a large number of pelvic inflammations, painlessly, without mutilation, without danger, in a short time, at a very moderate expense, . . . without the protracted convalescence or the aftermath that will follow so many cases that have been operated on for inflammatory conditions.

I wish to express my indebtedness to Dr. Holden of Bellevue, Dr. Cosgrove of the Margaret Hague Memorial Hospital, Dr. Kelly and Miss Mackin of the Jersey City Hospital, and the other members of the Staff of the Methodist Hospital for their courtesy and aid in this study.

[1] Gellhorn, G. *Bull. St. Louis M. Soc.*, June 5, 1931.

HYDRAULIC VICIOUS CIRCLE AS IT DEVELOPS IN ACUTE APPENDICITIS*

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EVIDENCE is accumulating that many bacteria normally pass into the blood stream without producing infection. The alimentary canal seems to offer a fairly free port of entry. Hydraulic vicious circle offers an explanation of the mechanical factors which allow bacteria to gain the ascendant over the resisting forces of the body, and produce infection.

This study centers largely about the functions of the capillaries, so beautifully expounded by Krogh. As long as the capillaries are freely open and deliver a normal supply of oxygen and nutrition, the tissues are able to maintain their mastery over the invading germs; but allow pressure to close the capillaries and deprive the tissues of oxygen, and the bacteria which are anaerobic or facultatively so will overcome the asphyxiated tissues and blood cells, and infection will take place.

This is the essence of this thesis, and the heart of the problem of the mechanics of infection, at least in the case of pus-producing organisms.

Following injury (destruction of capillaries) the presence of foreign bodies (including bacteria) or blood clots produces stasis of the blood stream. Local deoxygenation results. If no bacteria are present or only a few, especially when of mild virulence, the normal flow of fluid from a higher to a lower pressure will soon develop a stream away from the point of stasis, new capillaries and veins will develop, and normal conditions will be restored without allowing infection to take place.

When, however, the bacteria are sufficiently numerous and virulent to inflict casualties with debris, to further interfere with a free capillary circulation, a pocket will develop which will collect the exuding fluid and debris. Increasing hydraulic pressure in this pocket will further arrest the capillary flow and will establish the hydraulic vicious circle. The retarded blood stream, the resulting deoxygenation, and the histamine-like substances (toxins) will all add to the permeability of the capillary wall which hastens the effusion and completes the vicious circle: more pressure, more effusion, more pressure, more effusion.

Arterial pressure carries fluid in; venous and capillary stasis prevents its outflow; the filling pocket increases the stasis, which means more effusion and more pressure, until comparative equilibrium is reached. Just where is this equilibrium; that is, at what point of pressure in the pocket will further effusion cease? This is an interesting query which has not been fully answered. Of course, it will vary tremendously in the innumerable conditions to be found.

In experimental intestinal loops and in obstructions in the urinary tract, it has been variously measured as from 30 to 60 cm. of water. This is clearly sufficient to arrest the stream in the capillaries, which physiologists tell us normally runs from 0 to 10 cm. of water.

Who will contrive a device with which to calculate the pressure in abscess, appendicitis, gall bladder, etc.?

There are many other factors involved: Immunity, relative virulence, chemical, nutritional, osmotic, etc. This is an effort to cover only these mechanical factors.

The mechanics of hydraulic vicious circle are illustrated in Figure 1, an imitation appendix. The circulation is imitated by placing a very thin walled rubber tube between two toy balloons, one slipped over

* Submitted for publication October 19, 1931.

the other. At 10 cm. pressure (scale No. 1) blood flows freely through the blood vessels as in the veins and capillaries of the normal

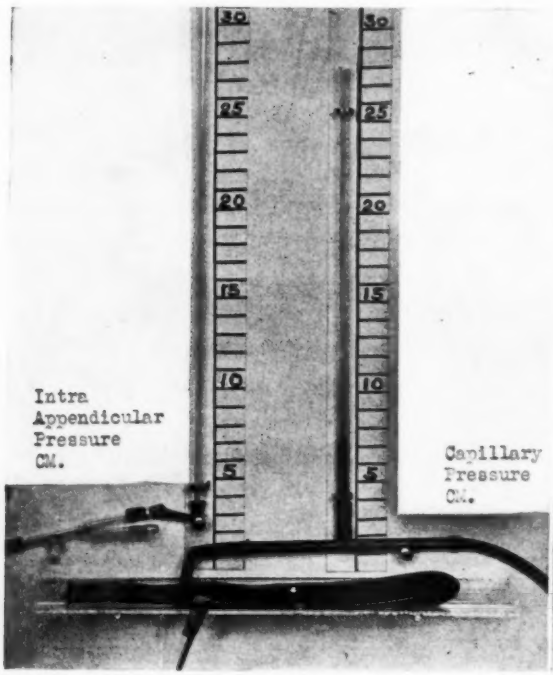


Fig. 1. Artificial appendix. Thin-walled rubber tube running to tip and back between two layers represents circulation in appendix. Pressure record on scale to right hydraulic pressure. In lumen of appendix on left. Normal capillary circulation (10 cm.) in healthy appendix shown by free flow from tube.

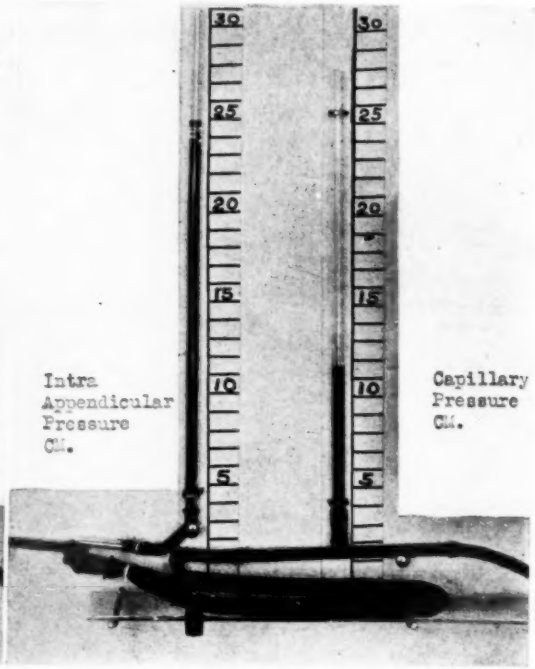


Fig. 2. Artificial appendicitis. Hydraulic vicious circle. Scale on right records hydraulic pressure in capillaries in cm. water. On left hydraulic pressure in lumen of appendix. Arrested circulation in capillaries of distended appendix (20 cm.) shown by absence of flow from tube (A). Distention means obstruction. Retarded blood supply means more effusion and more pressure.

appendix. Obstruct the lumen of the appendix and allow the hydraulic pressure therein to rise to 20 cm. (scale No. 2) and blood ceases to flow. The *hydraulic pressure* in the *lumen* is *higher* than that in the *veins* and *capillaries*, and closes them as by a clamp.

In 1907[1] I made a number of observations on the blood flow in the bowel wall as affected by varying pressures by means of a light within the lumen of the small intestine. It was observed that with distention of the intestine by a pressure of 30 mm. of mercury some capillary streams were arrested; at 60 mm., small veins were arrested, and in most veins the current was slow; at 90 mm. all blood streams were moving slowly, and many but not all currents were changing direction frequently; at 130 mm. pressure, all circulation ceased, and there was some oscillation of corpuscles but no progress. The following conclusion was made at that time: The demonstration seems complete that distention of the gut (or of other hollow viscera) interferes with the circulation in its wall, and allows infiltration and effusion to take place into its walls and lumen and any other open spaces which may come within its influence. The return circulation is retarded at comparatively slight pressures. Effusion follows, as in all obstructions to venous flow. As the average venous pressure in the intestine under ordinary circumstances probably varies from 4 to 10 mm. of mercury, any pressure beyond that will offer some resistance to the return current. Drops of fluid accumulate upon the surface of the gut, like beads of perspiration. Effusion occurs outside as well as inside the intestine.

This accumulating of fluid and its strangulating effect upon the circulation in

the intestine have also been demonstrated with distended loops by Morton,[2] Burget,[3] Dragstedt,[4] Owings,[5] Stone,[6] Weinberg,[5] and others.

Abscess. Abscess begins with the planting of pathogenic bacteria in tissues otherwise healthy and is nearly always the result of a wound, often microscopic and not observable from the surface.

The first step is pictured by Krogh in a footnote:

> In a microscopic field, containing in vitro, leucocytes and bacteria, a leucocyte, at a certain distance from the bacteria, becomes suddenly active and moves directly towards the bacteria, pushing the red cells in its way to right and to the left. Whatever the ultimate explanation of these chemotactic attractions may be, they are all important factors in the defense of the body.

The blocking of the blood vessels is immediately followed by edema at that point with resulting pressure on the veins and capillaries and the beginning of the hydraulic vicious circle: more pressure, more filtration of fluid, and more blockade of the blood vessels. Along with the effusion comes the escape of leucocytes. These leucocytes immediately begin the building of a wall of cells to stay the advance of the invading bacteria. This pyogenic wall forms a cavity in which the struggle between the body cells and bacteria goes on to the death of millions on both sides. These dead cells and bacteria plus the fluid (serum) which results from the hydraulic vicious circle constitute the pus of the developing abscess.

The fact that deoxygenation is present in this condition, follows inevitably from the retarded circulation (congestion), the prominent feature of hydraulic vicious circle.

Our sense of touch is sufficient to demonstrate that the pressure in a boil or in an inflamed appendix is much above the normal pressure in the capillaries and veins. In experimental production of obstructed loops of intestine, and in measuring the tension in the chronically obstructed bladder, we have records of pressure up to 50 and 60 cm. of water (Burget,[3] Morton,[2] Dragstedt,[4] Owings, McIntosh, Stone and Weinberg[5]). These pressures are more than sufficient to arrest the normal circulation in the capillaries and veins.

Another evidence of the great tension which is present in these conditions is the relief of pain which follows the opening of an abscess, such as a subperiosteal abscess, a felon, a post-tonsillar abscess, or even the pulling of a tooth where the pressure accumulating in the abscessed root causes excruciating pain. The great tension often present is evident from the spurting of the pus which is observed upon the opening of these abscesses. Those who have seen the discharge of pus under these conditions know that tension far beyond that sufficient to stop the circulation in the capillaries and veins is present. It seems strange that medical literature is so full of references to great tension in abscess, in the appendix, in knuckles of the intestine, hernia, gall bladder, and glaucoma, and yet no one, so far as I have been able to learn, has attempted to measure these pressures, or to estimate them, except possibly in the case of glaucoma.

Once the hydraulic vicious circle is established the further progress of the abscess is very simple. The principal attention is still centered upon the circulation. The hydraulic pressure in the pocket slows the circulation progressively up to the point of complete arrest. A slowing circulation means congestion and deoxygenation. The bacteria revel in the absence of oxygen and produce infection of an intensity depending upon the virulence of the bacteria and the immunity of the tissues. Strangulation is now complete, and necrosis and gangrene follow as a natural consequence of the arrested circulation, the deoxygenation and bacterial toxins. If death of tissue affects small areas, we call it necrosis. If large areas, it is gangrene. This is the mechanics of necrosis and gangrene, and thus is the mechanical arrest

of the circulation explained. Hydraulic vicious circle is responsible.

Deoxygenation. Haldane[8] says: "You, reader, will die of oxygen want. Your lungs, your heart, or that part of your brain which controls the respiratory muscles, will cease to play its part in oxygen supply and the energy transformation which makes up your conduct will cease."

The result of sufficient anoxemia is death. Anoxemia is a large factor in the death of tissue in necrosis and gangrene. Congestion, lack of oxygen, is one of the first results of hydraulic vicious circle.

Simply deprive normal tissue of oxygen and it will die. But deoxygenation adds another death-dealing element. It assists bacteria, especially anaerobic, to grow. It sets the stage for infection.

So far as I have been able to learn this step in the incidence and progress of infection has never been studied or discussed in medical literature.

Congestion, asphyxiation, deoxygenation are obviously and constantly present in the tissues surrounding abscesses, in appendicitis, and in intestinal obstruction. For evidence of lack of oxygen in these conditions I asked Dr. N. E. Burget to make some oxygen determinations in the intestinal loops which he is studying in dogs. In a personal communication he says:

> Preliminary work has indicated that the fluid from a loop distended and under considerable pressure contains very little oxygen. Fluids from non-distended loops contain a normal amount of oxygen, that is an amount similar to that of other body fluids. While we shall continue the investigation, the results indicate that the oxygen is used up by the anaerobic organisms when the circulation is blocked by distention of the loop.
>
> The action of anaerobic bacteria is in addition to the natural dissipation of oxygen from the congested area. I know of no data on the rate of disappearance of oxygen from an arrested vein.

The effect of this lack of oxygen upon the development of bacteria in this and other pockets is evident. Weinberg and his associates[9] found that practically one-half of the bacteria found in acute appendicitis are anaerobes, and it is generally accepted that the majority of pathogenic bacteria are *facultative* anaerobes. This is especially true of pus bacteria.

Acute Appendicitis. Acute appendicitis presents a perfect picture of hydraulic vicious circle, and it is natural that I should have found it first in this condition. Acute appendicitis is due to narrowing of the lumen of the appendix at some point in its length. The cause of this constriction may be a congenital malformation, a peritoneal band, a Jackson's membrane, an inflammatory scar formation, or any irregularity. The appendix is prone to irregularities in shape. A perfectly smooth, well-formed appendix will never suffer appendicitis. It is a common observation that as the appendix grows older, being a vestigial organ, it has a tendency to become more and more contracted and filled up with connective tissue (sclerosis). Other causes of narrowing are recurring acute attacks of mild appendicitis and peritoneal disturbances which may increase peritoneal bands and by contraction twist the appendix or kink it more sharply as time goes on.

Constrictions in the Appendix. For twenty-five years, I have looked for constrictions of the lumen of the appendix in acute appendicitis, and never in all that time have I failed to find some narrowing, provided that I had opportunity to make a complete study of the specimen, beginning before the appendix was disturbed from its bed. Pulling it up with the fingers may disturb peritoneal bands or straighten out kinks so as to prevent the casual observer from discovering the obstruction. This is nicely illustrated by Wilkie,[14] who shows how the appendix can be bound down by bands, causing obstruction, and how releasing these bands in order to bring up the appendix will relieve the obstruction, and the pathologist will be unable to find it.

Often the constriction is very near the cecum and in removing the appendix it

is severed at the point of obstruction, or even slightly distal to it. In that case, when the appendix reaches the pathologist it shows no evidence of obstruction or constriction. It is obvious that we cannot depend upon the pathologist's report as to the findings of narrowing of the lumen of the appendix. Sometimes the constriction is so slight that a casual study will fail to observe it, and still it will be sufficient to hold a fecal plug long enough to produce congestion and infection.

When one operates late in the progress of appendicitis, the appendix is often so much destroyed by necrosis and gangrene that the constriction is not easily recognized. It is the task of the surgeon to locate it, and if he will make a careful study, he will never fail to find it in any case which is worthy of the diagnosis of acute appendicitis.

In the early studies of appendicitis, edema and infiltration of the mucous membrane were frequently observed, and the natural inference was drawn that obstruction was the result of this edema and swelling of the mucous membrane. This theory has been repeated in the literature about appendicitis, but has no foundation in fact. The obstruction was present in the appendix before the infection began, and was not due to edema or swelling of the mucous membrane. Edema is commonly present in appendicitis, but I have never seen it cause obstruction. For the purpose of record I am suggesting the following classification:

A. Club shaped, congenital.
B. Kink, mesentery.
C. Peritoneal band.
D. Stricture, inflammatory or degenerative.

Obstructions in the Appendix. Next to the constriction, the obstructing plug is worthy of careful study. Since everything in the colon is classed under the head of "fecal matter," the obstruction is always composed of fecal matter or its derivatives. The most common obstruction is a plug of ordinary compressed fecal matter. This may be in the form of a firm mass, easily discovered, but often it is merely a mass of granular debris. I have removed dis-

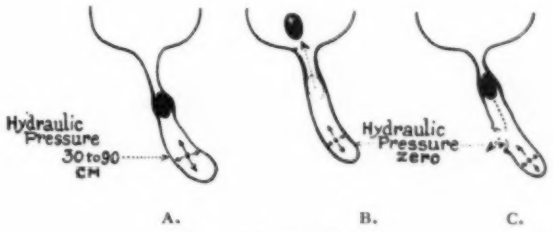


Fig. 3. Appendicitis.

A. Obstruction is followed by distention, congestion, anoxemia, prompt infection.

B. When rising hydraulic pressure drives obstruction into colon after one to ten hours, infection will be mild, "catarrhal."

C. When obstruction holds circulation is arrested. Necrosis, gangrene, perforation, peritonitis follow.

tended appendices, very evidently obstructed and with a marked constriction, and upon opening the appendix have failed to find any definite obstructing mass. One may find only granular debris which immediately mingles with the pus, mucus, and feces, in the appendix. Both of these forms of obstruction, whether a plug of feces or a granular mass, are so easily overlooked that it is no surprise that the element of obstruction in the appendix has so long eluded study. The next and more obvious type of obstruction is the concretion. This concretion, developing as it does in the very mouth of the constriction in the appendix, will naturally be shaped to fit the constriction and will produce a perfect ball valve.

Development of Concretion. Fecal matter consists of a mass of remnants of food together with numerous bacteria. These masses pass into and out of the appendix freely. Being naturally of a sticky nature, one mass will adhere to another and after they have passed the constriction, will become fused in the cavity beyond. As more passes into the appendix, the lump will grow in size.

The peristaltic contractions of the appendix will drive out the fluid parts of this mass, leaving the more inorganic solid matter behind. All parts of this mass which

are digestible and soluble will be digested and dissolved by the bacteria and secretions and will pass out into the colon. During this process the mass becomes more and more indigestible, until only cellulose and salts, mostly calcium, remain. Held by a constriction, a small concretion will, in the course of years, grow by gradual accretion, until some shift of position fits it into the constriction firmly and blocks the lumen of the appendix. This process may continue for years, sometimes a lifetime, before anything further results than the formation of a concretion. For the purpose of record and study, I am suggesting these three types of obstructions:

1. Concretion.
2. Fecal mass.
3. Debris, including appendiceal contents in which no definite obstructing mass can be identified.

Physiologically the contents of the cecum have free access to the appendix, and, undoubtedly, more or less of the contents of the cecum are constantly passing into and out of the appendix. Numerous observations by many roentgenologists have established this fact.

With the constriction established and the obstruction formed, whether it is a fecal mass, a mass of debris, or a perfectly fitting concretion, the stage is all set for an attack of acute appendicitis. All that is now necessary to spring the trap is to have something fix the obstruction in the constriction. This may proceed very quietly by simple peristaltic contraction forcing the plug into place and holding it there long enough for the normal secretions of the appendix to press it home. In other cases the colon, with its contents in an uncommonly liquid condition, or in large amount, by a sudden contraction will force sufficient fluid into the appendix to push the plug into place with a snap, closing a perfect ball valve, and will immediately produce considerable hydraulic pressure in the appendix cavity. Undoubtedly many of the extremely acute attacks which come on suddenly with excruciating pain are of this type.

Whatever the cause of the closure of the ball valve, the first result is the accumulation of secretions behind it. All mucous membranes secrete more or less fluid and mucus, and in the beginning it is probably the normal secretions which begin the distention. As soon as a pressure equal to that normally present in the veins accumulates, there will be a slowing of the circulation and a beginning of the hydraulic vicious circle. This is in the neighborhood of 10 cm. of water pressure. Once this point is reached, the increase will be more rapid, as the fluid now leaves the blood vessels largely by filtration. Hydraulic vicious circle is now established and will take the same course it does in abscess. If the obstruction is compressible, or the constriction dilatable, or both, this pressure, when it reaches a point sufficient to force the obstruction past the constriction, will drive it back into the colon. If not, a virtual abscess results and goes on to necrosis, gangrene, rupture.

The Obstruction Gives Way. If there is but slight obstruction it may give way in a very few minutes. It may produce only a twinge of colic, in which peristalsis of the appendix plays an important part, and practically no other symptoms. There may be a mild infection which may add to the irregularities and constrictions of the appendix by scar formation. The obstruction may last so short a time that only a beginning hydraulic circle will be established. A longer period of obstruction will produce greater pathologic changes and, of course, if it does not give way within twenty-four or thirty-six hours, necrosis, gangrene, and rupture follow. All the various pathological conditions found in acute appendicitis, often to the extent of prompt gangrene of the entire appendix, may take place, depending upon the firmness of the obstruction and the virulence of the infecting bacteria, and the length of time the obstruction holds. If the obstruction gives way within a couple of hours, a mild infection will be the result.

Immediately after the tension is relieved there is free drainage, the circulation is restored, oxygen is again supplied in abundance, and in a few minutes the picture is entirely changed. This change is often very apparent to the patient as he sometimes suddenly feels the relief from pain and declares that he is feeling much better.

If an appendix is removed soon after this point in the attack, it will be found very much congested and the pathologist will say that it is infiltrated. It is acute appendicitis, and if the obstruction has held for only a short time (one hour), it will be of mild character, probably confined to the mucous membrane of the appendix. In other cases, where the obstruction has held for four or five hours, we find traces of necrosis, and in many hemorrhagic infarcts and often free hemorrhage into the appendix, evidence of the strangulation which had been present.

It is not my purpose to dwell upon the various types of pathology which follow this temporary obstruction of the appendix, with temporary establishment of hydraulic circle. Probably a majority of the appendices removed in the average clinic will fall somewhere in this class. There is first the frankly superficial infection of mucous membrane, often called catarrhal appendicitis. Obstruction for a little longer time will allow the infection to involve the submucosa, and from there on the inflammation will extend to varying depths into the wall of the appendix, depending upon the length of time the obstruction was present. More and more of the circulation will be involved, with more and more petechial infarcts, and often more or less free hemorrhage into the appendix. Superficial and deep inflammation, edema of the mucous membrane, sometimes filling the cavity of the appendix, superficial necrosis, in fact all of the conditions which follow acute strangulation with infection, depend upon the length of time that the appendix was obstructed. If the obstruction does not give way before mass necrosis occurs, rupture of the appendix will follow.

We know that with free drainage into the colon which follows escape of the plug the patient will recover from this attack very promptly; and even where no operation is done, such patients recover quickly. There will be a little rise in temperature from the mild infection, tenderness for two or three days, slight lassitude, and some digestive disturbances. But we have here the picture of an abscess which opened very early, before it had fairly begun, and in which free drainage is followed by prompt recovery. At the same time, removal of an appendix after an attack of this kind is advisable because the victim of such an attack is almost certain to have further attacks. Our study of obstruction has shown that these attacks are nearly always followed by an increase in the degree of constriction.

How can we demonstrate that such an obstruction has been present and that such a plug has been driven out? This is the constant challenge of the pathologist and of the clinician. To me, and to many others, the conclusion is obvious from the premises, especially when supported by the condition of a large number of appendices which we see removed during the stage of obstruction and distention. Mechanically it seems obvious that the plug will often be driven out. We know that hydraulic pressure rises behind it. We are constantly finding appendices distended with fluid, ready to burst. Rising pressure drives a bullet out of a gun; why should not pressure drive a fecal plug out of an appendix.

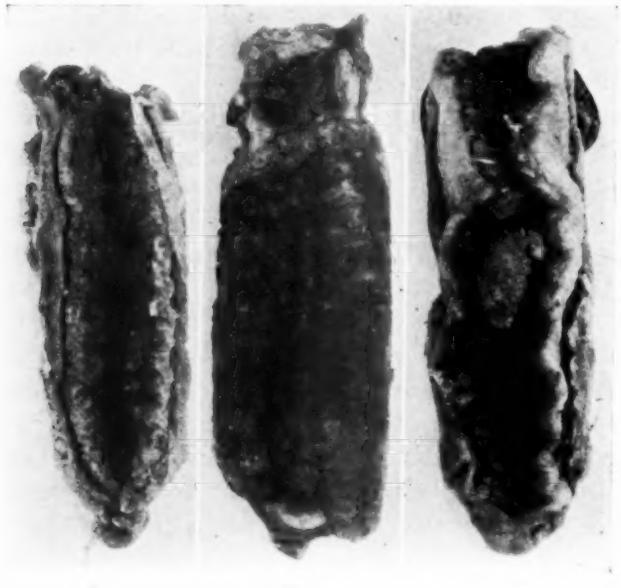
Outside of the blood vessels very few pressures in the body have been studied. Hence to determine the pressure necessary to empty the rectum, I provided a glass tube with scale attached to connect to the enema can and asked a couple of nurses to record the pressures developed by different patients in expelling their enemas. They reported an average range of 30 to 40 cm. Should it take more pressure to force the same sort of material from the appendix than from the rectum? Is it not logical that as these pressures are reached in the dis-

tended appendix the fecal plug will be driven out?

Professor Wilkie[10] tells of feeling a concretion in a distended appendix which, after manipulation he felt slipping into the cecum, where it was distinctly identified.

Dr. Addison H. Bissell of Stamford, Conn., in a private communication, reports the following interesting case:

> One case was a pretty demonstration of your contention. I exposed a typical "red hot" appendix. As I put my fingers under it to lift it out, there was a decided "plop," and the appendix collapsed like a punctured tire. The material in the appendix could be seen to squirt into the cecum. Palpation showed a concretion in the cecum. There was active peristalsis in the appendix, and it wiggled like an angle worm. The color receded to practically normal in about a minute as we stood and watched it. I was tempted to sew up the abdomen and leave the appendix in, but did not have enough nerve. The lumen had constrictions in it, and by the proximal one, the mucous membrane was ecchymotic. We watched the stools, and, *I am sure, saw the concretion.* It never occurred to me to fit it in the appendix.



A. B. C.

Fig. 4. Appendices, showing effects of distention.

A. Constriction at cecum lost in amputation; obstruction, six hours' acute catarrhal appendicitis; appendix congested, edematous; infected mucosa.

B. Appendix distended at operation eighteen hours after onset; proximal, one-half inch normal; acute appendicitis; sharp line of demarcation at constriction; strangulation; small hemorrhages and beginning necrosis.

C. Appendix distended at operation eighteen hours after operation; concretion at constriction; sharp line of demarcation at constriction between normal and strangulated tissue.

Personally, I have several times seen a fully distended appendix as suddenly lose its distention and become flaccid and empty under manipulation while I was removing it. Many surgeons must have had this experience of having the obstructed appendix suddenly emptied during the manipulation of the removal, and doubtless many have felt the concretion in the cecum afterward. Then why does it seem so strange that the accumulating pressure behind the obstruction should drive many, most plugs, out into the cecum?

Obviously, once the obstruction is removed, the recovery will be prompt. Upon removal such an appendix will be found infected: red, congested, inflamed, edematous, hemorrhagic, usually empty, sometimes containing bloody serum and mucus.

The three appendices photographed in Figure 4 illustrate some of the difficulties

in demonstrating the plug. In A (T.M.) the appendix was found at operation entirely empty, the plug, judging from the symptoms, having held about six hours and having been driven out about six hours before operation. B (N.W.) and C (Mrs. H.S.R.), were both removed eighteen hours after onset of the attack and the appendices were both found blocked and distended. The pathology, you will agree, is practically the same except that B and C are further advanced towards necrosis than A. In A the constriction, which was very marked, was at the cecal junction and was left in the ligature and suture which closed the cecum. The pathologist would never see it. In B the constriction is very well marked, and a half-inch of normal appendix entirely free from pathology shows proximal to the constriction. The sharp line of demarcation of pathology at the line of constriction is strikingly illustrated.

In A the evidence in the history was so typical that the plug had given way at a well marked time. The nurse was offered ten dollars for finding the plug which had caused the six-hour obstruction. She produced a fecal mass of about the proper size at the first emptying of the colon five days after operation. It was soft and dried so rapidly that it is hardly a demonstration that this was the identical plug which held that appendix distended. We can say that it is suggestive evidence.

Case B illustrates the variety of obstructing masses one finds and the difficulty of demonstrating a definite plug in some cases. The appendix was removed intact, fully distended, with marked tension to the examining finger. Upon opening it, we found it filled with the usual mass of debris: pus, mucus, fecal masses, traces of blood, but no one distinctive mass which could be charged with having closed the constriction, which was of considerable size. The obstruction and distention were there, demonstrated beyond peradventure before opening, but the obstructing mass was soft and unstable in its consistency, only a mass of debris. A casual search would have failed to find it. It cannot be left to the pathologist. The man who sees that appendix in situ must demonstrate the obstruction. The distended appendix under tension was proof that the constriction, which is evident in the photograph, was closed by some sort of mass. It was in the appendix when it was opened. This mass was simply a part of the general fecal remains which, with serum and pus, filled the cavity.

Often the obstructing mass is overlooked in a casual search. I have had the experience several times of finding a distended appendix at operation, but failing to find any definite mass or concretion to close the constriction. I can always find the constriction and, when distended, always debris behind it, but I do not always find demonstrable ball valves with pretty concretions.

Case C illustrates another difficulty in demonstrating the obstruction. I nearly lost the concretion which is seen obstructing it at the constriction. The appendix was removed with the obstruction and distention intact. The distention was extreme. When it was opened, there was a rush of bloody pus and debris. The scissors which opened the appendix pushed the concretion into the appendix as it was forced through the constriction, and it required a very careful search to find it floating in the mass of pus and debris. A casual search would certainly have missed it. Again I implore my surgeon friends to make careful search for both the obstruction and the constriction. They are all-important to the understanding of appendicitis, and so easily overlooked.

Note the similarity of pathology in A after six hours of strangulation and infection, and in B and C after eighteen hours of strangulation and infection: in A acute catarrhal appendicitis; in B and C with petechial hemorrhage and beginning necrosis added; in all, inflammation practically confined to the mucosa and submucosa.

Note the distinct line of demarcation between healthy and diseased mucosa *at the point of constriction*. Can anyone doubt

that strangulation, arrest of circulation, congestion and anoxemia, *distal* to the constriction had been present?

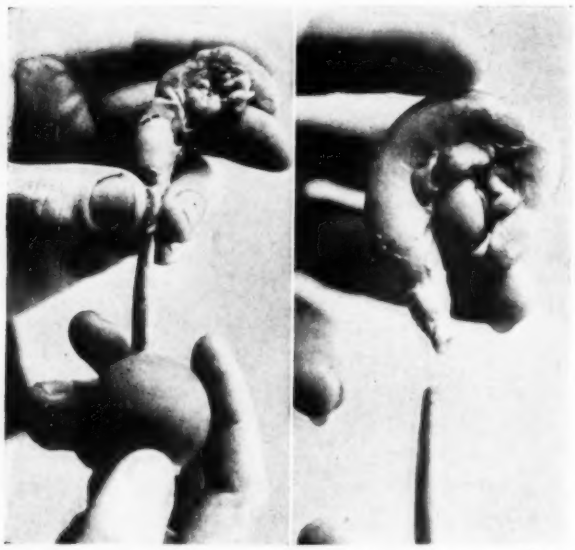


Fig. 5. Appendix which discovered the cause of appendicitis. The concretion made a perfect "ball valve." By manipulation it could be easily displaced and the appendix emptied. Again it could be easily filled with fluid from a bulb syringe; the trap would spring and a perfect, distended gangrenous appendix would result.

Operate early and you will find the distention often and usually a demonstrable plug in the constriction and abundant evidence of strangulation and anoxemia.

The Obstruction Holds. All surgeons have experienced the thrill of finding an appendix, as expressed by Dr. Bissell "piping hot." That is, when the abdomen is opened the appendix is found still distended, showing evidence of inflammation, necrosis, and gangrene, often in imminent danger of rupture. The satisfaction of finding such an appendix before it ruptures comes from the chance to rescue one's patient from a catastrophe which is all too common.

Figure 5 is an appendix* which started me on a study of the causes of acute appendicitis, and of hydraulics generally and particularly of hydraulic vicious circle.

Mechanically, the onset of acute appendicitis is always the same. The plug closes the constriction, the appendix balloons out with fluid, and the hydraulic pressure of this fluid retards the circulation. In one patient, the obstructing mass passes into the colon. In the other, the obstruction holds, and the hydraulic vicious circle continues its course exactly as it does in abscess. In fact acute appendicitis is acute abscess. In both conditions strangulation is the major fact in the pathology.

The continually increasing pressure in the appendix interferes more and more with the circulation in its walls. The congestion, anoxemia, the virulent growth of bacteria, all confined in this closed pocket, make quick work of the oxygen-demanding tissues. Capillaries, veins, arterioles, arteries, are successively closed by this pressure; strangulated. The pathology is the pathology of strangulation. It centers about blood vessels and blood pressure, hence it is living pathology.

Early in an acutely distended appendix, hemorrhages are common. These are the result of obstruction to the blood stream and the weakening of the vessel walls due to stretching, and necrosis from the toxins of bacteria. Edema of the mucous membrane is a result of the same forces, fluid being forced out of the vessel walls by the pressure behind and the obstruction ahead.

Clinical Application. The symptomatology, the history, and the pathology fit perfectly into this mechanical explanation. The patient, apparently in perfect health, discovers he has an abdominal pain, a colic. The appendicular trap has sprung. This first and most characteristic symptom is the result of the peristaltic contraction of the appendix in its efforts to empty itself. This first pain is usually referred to the upper abdomen and is often slight and easily forgotten. Nearly all abdominal disturbances are referred to this region of the solar plexus, especially in their early stages. If, after a few attempts, the appendix succeeds in emptying itself, the patient is relieved, and goes on, often without suspecting appendicitis. He has had appendicular colic.

* Also illustrated in *J. A. M. A.*, 1904.

The location of this pain is the subject of a great deal of study and is fully covered in the literature. In brief, it is usually referred to the stomach region and is usually first associated with a digestive disturbance. The pain may radiate in all directions, and sometimes at an early stage points to the lower right corner of the abdomen, the appendix region. The fact that the initial pain usually does not begin in the region of the appendix has resulted in the loss of many lives. The trained surgeon has thoroughly learned this, and even the laity is becoming better informed. The peristalsis seems to be communicated to the intestinal tract from the contracting appendix and produces general colic.

The Exact Hour of Onset. The most important fact in the history of acute appendicitis is the exact hour of the onset of the attack. Knowing that the rupture occurs within thirty-six or forty-eight hours, we read the stage of the pathology by pinning the clinical and examination findings to this fixed time. Unfortunately, in the beginning, the symptoms are often so slight that it is difficult to fix the time with certainty, but careful quizzing will usually establish the point.

For instance, I asked a little girl when she first felt the stomach-ache. Her father answered for her, "This morning." After two or three more queries, the little girl said, "No Daddy, don't you remember that I had that pain when we climbed the hill yesterday?" It fixed the time of onset in this case, which proved a very important guide in the treatment.

The time normally intervening between the first onset of pain and the rupture of the appendix being so definitely established, and being so short, makes the fixing of this point obviously very important. We cannot urge too strongly the accurate establishment of this time of onset, as it is the cue to the further history and progress of the disease. Without it we are at sea as to the present pathology. I have taken ten or fifteen minutes quizzing to establish this one point. If that can be absolutely fixed, the further study of the history and picture of the disease is usually easy. Much of the mortality in appendicitis is due to the failure to fix accurately the time of onset. In many cases the obstruction began a day or two days earlier than the time first mentioned by the patient.

Soon after the onset of colic, the pain becomes more of a continuous ache, interrupted frequently by "colicky" attacks. The next important point is to locate the probable time at which the obstruction was automatically relieved by emptying into the colon, if that fortunate event has occurred. This may occur within an hour of the onset, and it may be delayed for twelve or even more hours. Sometimes this point cannot be definitely determined, but in the majority of cases careful quizzing will elicit the story of a decided and comparatively sudden easing of pain, especially that of cramp-like character. A steady ache and a tenderness will continue for hours and days, but the "colicky" cramp-like character of the pain is usually absent after the obstruction has passed out into the colon. In fact, in many cases it ceases instantly, and the time of the passing of the plug can thus be fixed to the minute. The evidence of the peristaltic wave which begins in the appendix and probably spreads over the alimentary canal generally is a colic, and if a distinct history of colic can be elicited from the beginning of the attack to a sudden cessation when the plug leaves the appendix, the pathology can then be definitely read.

This sudden let-up due to emptying of the appendix must be carefully differentiated from the *gradual* easing of pain which follows the deadening effect of the destruction of tissue by the infection and circulatory stasis: in other words, the beginning gangrene. Sometimes this comes on early enough to be confused with the cessation which accompanies the driving out of the obstruction, and sometimes it may in fact develop rather suddenly. This is one pitfall which must be always kept in mind and cannot always be avoided, espe-

cially in young patients or those who are not very clear or accurate in differentiating the character of pain which they suffer. I should be very presumptuous if I stood out for a dogmatic statement that one can *always* be positive as to the time of relief of this obstruction. But the evidence in the majority of cases is sufficiently positive to allow us to say that the probabilities are 10 to 1 that the obstruction has passed into the colon. The urgency of operation obviously turns upon this question. It is always an advantage to the patient to have had his appendix removed, and where there is any doubt, there should be no hesitancy in removing it at once.

The further history when the obstruction does not give way comprises continuing colic, increasing malaise, fever, and toxemia, and the establishment of a constant ache, more or less colicky, in the abdomen, which very commonly is referred to the appendix region as the disease progresses. Then, after twenty-four or thirty-six hours, we have the easing up of the colicky character of the pain and often a very decided subsidence of all pain and the assertion by the patient that he feels very much better. Following this, at approximately thirty-six to forty-eight hours from the time of onset, comes the evidence of rupture of the appendix as the infection spreads to the peritoneum. Often there is quite a lull and a subsidence of all symptoms, and an expression of relief on the part of the patient at the time of the rupture, but the peritoneal infection develops so rapidly that in an hour or two the patient is aware of a new attack, and, if he is discriminating in his evaluation of the character of the pain, he realizes that his abdomen has taken on a very different program.

The eliciting of this information from the patient is very important in making an accurate diagnosis of the condition present, because from now on, probably during the next twenty-four hours, the debate as to the advisability of operation is most acute on the part of the attending physician, the patient and his friends, and with varying opinions even among expert surgeons. Often there can be no doubt of the condition; in others, all the factors in the case must be very carefully studied in order to determine whether the obstruction has escaped into the colon or whether a rupture has taken place. The most important factor in the case is the history. Fix the hour of onset, the time of the different types of pain, and the times when the character of the pain changed.

It cannot be repeated too often that, once the diagnosis of acute appendicitis is made, more information about the actual condition can be secured from a careful quizzing as to these factors of time and the character of the pain than from any other signs or symptoms. This is not minimizing the importance of the temperature or the question of leucocytosis or the elimination of other diseases. All the diagnostic factors which have piled up around this condition are important and must be evaluated, but for a picture of the actual pathology, the emphasis should be upon the time sequence in the history.

Two terrible scourges have been definitely marked off the unavoidable mortality list by science. There is no longer an excuse for a death from diphtheria or from appendicitis. In the former, give antitoxin, and give it early. In the latter operate and operate early. The diagnosis can and must be made early. Twenty-four hours is the limit. It must be admitted that the rare case presents when this is impossible, but I must repeat that such cases are very seldom encountered.

In appendicitis, this advice will never be realized until medical men and the public generally see obstruction as the cause and realize that the specter of strangulation lurks in every acute "stomach-ache." Appendicitis must be eliminated or established in every case of acute abdominal pain, and it must be done during the *first twenty-four hours from the time of onset*. The patient must be seen every couple of hours until the diagnosis is made. And with this

picture of obstruction and strangulation in mind, operation will be done within these first twenty-four hours. This is the great urgency in this study. For early operation will not be done until the picture is clearly in mind. The tragedies, the tragedies! If we had only operated early! When will the medical profession learn the lesson from these tragedies? In its beginning appendicitis is only a pimple but potentially it is a bomb about to explode in the vulnerable abdomen.

Pathology of Appendicitis. From the earliest studies of appendicitis, pathologists have always stressed the changes in the blood vessels. Obstruction, edema, infiltration, hemorrhage, necrosis, and gangrene all play an important part in the pathology, all are evidences of interference with the circulation, and all are illuminated and explained by the hydraulic vicious circle. The variations from simple infiltration in the mild cases to the more profound circulatory disturbances in the necrotic and gangrenous cases only mark the different degrees of the progress. The presence of microscopic hemorrhage, and often considerable amounts of blood found in the early stages, cannot be explained on any other basis than that of mass involvement of the circulation, in the hydraulic vicious circle. It is the pathology of strangulation.

Unfortunately, the pathologist sees the appendix only after it has been removed from its attachment, and he is handicapped in connecting his pathology with the physiology of the circulation; so that his explanation of the circulatory changes is bound to be incomplete. When the appendix is removed, its circulatory system is severed from the hydraulic system of the body and from the standpipe (heart), which has kept up its blood pressure, and consequently from the basis of all physiological activity. The study and correlation of the living physiology of circulation, with the pathology of acute appendicitis is urgently needed.

In 1896 Dieulafoy[12] made the approach to the obstruction theory of the cause of appendicitis with his designation "cavite close." He said, "Appendicitis is always the result of the transformation of the appendicular canal into a closed cavity."

Since Dieulafoy's time, numerous writers mention stagnation and lack of drainage in the appendix as factors in causing appendicitis, and in a vague way lack of drainage is generally put down as one of the causes. In 1905, I[13] described my ideas of the closed cavity and the method of closure as with a ball valve. I was the first to declare that the circulatory changes were due to the hydraulic pressure within the lumen of the appendix. Also, that the acute onset, and the rapid progress of the disease are the result of mechanical obstruction. I obstructed the appendix in dogs and described the effect of both the temporary and permanent closure. In 1907, I[1] published the results of some experiments demonstrating the arrest of circulation in their walls by distention of hollow viscera.

In 1914, Wilkie[14] reported some experiments on rabbits and cats illustrating his ideas of acute appendicular obstruction. His emphasis was put upon the character of the content of this closed cavity, finding that animals fed chiefly on a diet rich in proteids would develop a more acute and destructive type of infection than those fed on a carbohydrate diet.

Morton[2] describes experiments showing the effect of distention upon hollow viscera. His work was done in studies of intestinal obstruction.

Dragstedt, Lang, and Millet[4] described some similar findings in 1929 and Burget and Martzloff in 1930[3] described some similar experiments in this same line of study.

These authors confirm my explanation of the strangulating effect of distention of hollow viscera.

Recently demonstrations have been made by several investigators of the effect of entirely closing the appendix by ligature or suture in dogs.

Distention, infection, and gangrene have been the results, the effect being practically identical with those observed in experi-

mental loops of bowel. (Dragstedt, Coller and Butterfield[15]—results to be published later.)

If surgeons would repeat the manipulation which started me in this study (see Fig. 5), they would soon be convinced. They should relieve the obstruction by pushing the concretion up into the appendix and at will fill it again with fluid from a syringe. It would make this mechanical closure real to them. Any appendix distended behind a large sized concretion will make the demonstration. It is a picture of what is happening every day.

The infective process is of course the result of the activity and growth of the pathogenic bacteria always present in the appendix in great numbers and variety. Colon bacilli, staphylococci, streptococci, and a host of others, one-half anaerobes, need only an opportunity to become very active. Lack of drainage, anoxemia, open crevices in the mucous membrane and infection are prompt. Millions develop in a few hours.

CONCLUSIONS

1. The proximate cause of acute appendicitis is a narrowing of the lumen of the appendix.

2. The immediate cause is a fecal mass or concretion lodging behind the constriction, causing a closed cavity containing a foul, putrefying, infective mass, developing a hydraulic vicious circle.

Further steps and factors are: (a) the cavity fills with fluid to a pressure upward of 30 to 50 to 70 cm. water; (b) this hydraulic pressure closes the blood vessels in the mucosa and walls (Fig. 2); (c) circulatory stasis results; (d) congestion; (e) effusion, edema; (f) strangulation; (g) anoxemia; and (h) anaerobic mastery and infection, since appendicular bacterial flora is predominantly anaerobic.

Final Majority: The rising pressure plus muscular action drives the plug with the foul mass into the colon, leaving perfect drainage, a restored circulation, and prompt recovery from a superficial (catarrhal) appendicitis.

Minority: The obstruction holds against all pressure; necrosis, gangrene, rupture, peritonitis, etc., follow. All grades and types are possible from these beginnings.

Chronic Appendicitis. Chronic appendicitis has as a rule quite a different pathology. Occasionally inflammation, beginning with an acute attack, will continue to grumble and leave some of the changes commonly noted by pathologists as evidence of chronic appendicitis. However, most of the pathological changes classed as chronic appendicitis are the result of the natural degenerative changes which are constantly active in a vestigial organ.

The appendix in the human is the evolving remnant of a very useful organ in many animals, especially herbivorous. Much infiltration of leucocytes naturally accompanies this degenerative change.

I fear that the report of chronic appendicitis by many pathologists is predicated upon the desire to support the surgeon in his original recommendation of appendectomy.

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SLOUGH PREVENTION IN THE INJECTION TREATMENT OF VARICOSE VEINS

BY A NEW DYE METHOD*

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ONE of the complications that is greatly dreaded in the injection treatment for varicose veins is the occurrence of slough formation.

A slough or area of wet gangrene is due usually to the accidental injection of irritating fluid outside of the vein. No solution as used at the present time is free from this danger. Even the newcomer to the group of vascular irritants, sodium morrhuate, has been reported as capable of producing a slough. Knowing that we cannot depend upon any solution to avoid local necrosis, we are forced to rely upon faultless technique in order to avoid this complication. However, even with apparently good technique, a perivascular injection can be made without the operator's knowledge. This is illustrated in Figure 1.

In Figure 1A, the needle is in the vein and on sucking back with the syringe blood is aspirated. However, the vein has been punctured in several places during the search for its lumen, and solution may escape through these holes to cause a slough. In B, the needle point lies in a hematoma caused by a stab in the vein wall. Blood returns on aspiration to deceive the operator. In C, the needle has not been wiped free from excess fluid and some will be deposited in the needle track on entering the tissues. In D, a long bevel needle is partly in and partly out of the vein. The fluid finds its way outside the vein, but aspiration draws blood. In E, a thin-walled vein has been torn after having been pierced by the needle. A leak in the vein wall is the result.

It can thus be seen how a perivascular injection can be made in the face of apparently good technique. The operator often cannot definitely know that an accident has occurred and will neglect to neutralize an offending escaped solution; a slough may be the result. The problem, therefore, is to be able to detect the immediate introduction of fluid outside of the vein. The dye method was developed to answer this need.

PRINCIPLE

Methylene blue is incorporated in the injecting solution so that any escape of fluid into the tissues demonstrates itself as a dark stain. In the preliminary trial of this method we worked with a 40 per cent solution of sodium salicylate. Using such a strong irritant was considered a severe test of this new technique.

ARMAMENTARIUM

Two salicylate solutions are prepared: one, the usual 40 per cent solution in sterile distilled water; the other, the same solution containing in addition 0.4 per cent methylene blue. This sterile colored mixture is kept in a rubber-stoppered bottle of the type that vaccines are dispensed in. When fluid is needed for injection, it is secured by piercing the rubber stopper, thus keeping the remainder of the mixture sterile.

The syringe is a B-D intravenous type, of 3 or 10 c.c. size. This syringe, as illustrated, is so constructed that the tip, which is at an angle to the barrel, has in it a small bulbous dilatation. The bulb is in communication with the barrel by a small capillary channel. This arrangement prevents the mixture of the contents in the two chambers. As will be shown later, the

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separation of the contents of barrel and bulbar tip is an important mechanism of the dye method. The smaller 3 c.c. intra-

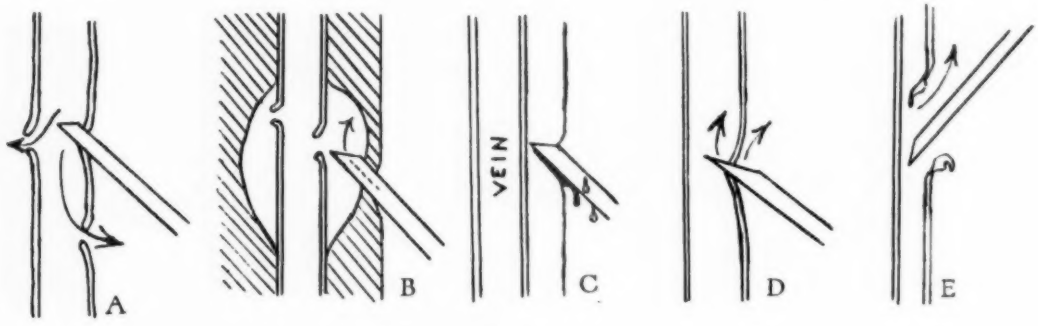

Fig. 1.

venous syringe will soon be available to the profession. It has been made at our request in order to fill a need for a small instrument of this type and will be found generally

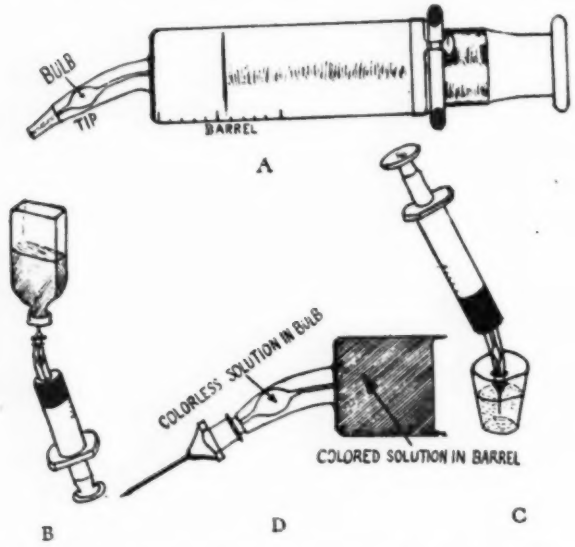

Fig. 2. A. Construction of empty syringe. B. Aspiration of dye-colored solution from bottle. C. Sucking up colorless solution from medicine glass. D. Shows final result of mixture in syringe.

useful where varicose vein injections are called for.

The needles are of the short-bevel type, 21 or 23 gauge, and preferably made of steel.

TECHNIQUE (FIG. 2)

1. The needle with syringe attached is plunged through the rubber stopper and 1–2 c.c. of the dye-colored solution is aspirated. This is about one-half of the total amount of salicylate to be used. After this the air is expelled from the syringe, and the needle wiped clean with an alcohol sponge.

2. Then the colorless salicylate solution is sucked up from a sterile medicine glass. It is important to do this very slowly so that no air is aspirated. Enough of this solution is drawn up to make a total of 3–4 c.c. in the syringe. During this procedure the syringe is held perpendicularly with the needle pointing down. As this is done, it will be seen that the bulb in the syringe tip becomes decolorized while the colored mixture is drawn up into the barrel. When we finish, we have in the same syringe a colorless and a blue solution, each segregated into different compartments, which do not mix.

3. The needle tip is wiped off with an alcohol sponge and the injection made as usual.

Upon entering the vein, blood is aspirated into the capillary bulb of the syringe tip, where it can be distinctly seen against the background of the colorless salicylate solution. As the injection is made, a blue stain around the needle area is a signal that fluid is entering the perivascular tissues. This is a signal to stop the injection. If no discoloration is noted, we wait thirty seconds and then withdraw the needle. Further treatment is as usual.

In the event of a perivascular accident, the first step is to aspirate in the hope of sucking back some of the escaped fluid.

Then the bluish area is flooded widely with at least 10 c.c. of normal saline solution or distilled water. Distilled water is thought by some to be a better diluent, but it must not be injected into the vein. Neutralization will not always prevent a slough. However, with the guidance of the dye, a poor injection will be promptly stopped and a minimal amount of tissue destruction will result. Prompt dilution of the small amount of escaped fluid will therefore exercise its greatest benefit. In our experience, no sloughs have resulted where the blue discoloration, indicative of an extravascular injection, has been promptly neutralized.

An interesting phenomenon takes place as the injection is made. This is the appearance of the colored fluid as it is seen traveling through the varicose veins. The solution can actually be visualized as it courses through the venous channels. The flow is usually downward, and sometimes both up and down. As it moves downward it spreads through the smaller veins where it lingers to subside slowly. During its diffusion over the surface vessels of the leg, the patient experiences a cramp-like pain. This observation shows that the cramp resulting from irritating injections is not due to vascular or muscular spasm. The pain apparently depends upon the irritation of a sufficiently wide bed of venous channels. As a further proof, we have noted that when the fluid is localized to a vein segment by pressure, no cramp occurs until the pressure is relieved and the fluid allowed to spread through the network of smaller superficial veins. The amount of downward flow is roughly proportionate to the degree of varicosity.

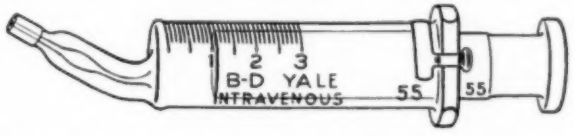

Fig. 3. New 3 c.c. varicose vein syringe, as suggested by author, and used in this technique.

At the German Polyclinic Hospital we have used this method for the past year in 72 cases, employing it whenever sodium salicylate was indicated. In addition to salicylates, of course, we use all other solutions. Our rule is to use the least irritating solution that will produce the desired effect. In the future, we hope to extend the dye method to other irritating preparations.

CONCLUSION

1. The avoidance of sloughs, in the light of our present knowledge, depends less upon solutions than upon technique.

2. Even with apparently good technique, sloughs may occur, because a perivascular injection can be made without the operator's knowledge.

3. With the dye method of injection, we have a definite indicator of a perivascular accident. This is a signal to stop the injection and neutralize.

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INJECTION TREATMENT FOR VARICOSE VEINS

WITH SPECIAL REFERENCE TO ATTENDING DANGERS AND COMPLICATIONS. REPORT OF A CASE OF CONGENITAL ARTERIOVENOUS FISTULA*

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THE phenomenal success of the treatment of varicose veins by the injections of escharotic solutions has become so well established that this method has practically displaced all other procedures. The voluminous literature that has appeared in the two or three years last past is so convincing of the superiority of the injection method over that of operative measures, that seldom can anyone now be found to defend any of the older methods of treatment. The injection method relieves the patient of all dread of anesthesia, the mental terror of operation, and hospital confinement and permits him to continue his accustomed vocation, and reduces the total expenses at least one half.

FIG. 1. H. R. McG. Congenital arteriovenous fistula, right lower extremity. Note enormously enlarged veins of dorsum of foot and anterior aspect of leg and thigh. Other equally enlarged veins on outer and posterior surfaces not shown in picture. Note further, normal left lower extremity.

FIG. 2. H. R. McG. After treatment. All vessels obliterated by use of massive doses of quinine and urethrane.

The mortality rate following excision as shown by Kilbourne[1] was one in 250 or 0.4 per cent. Kilbourne's record was derived from a questionnaire submitted to thirty-four large hospitals with a total of 4607 cases surveyed and a mortality of 16, 8 of which were due to embolism. McPheeters and Rice,[2] on the other hand, collected

* Submitted for publication July 13, 1931.

reports on upwards of 53,000 cases treated by the injection method with 11 deaths or about 2 in 5000. Some of the deaths in Kilbourne's cases undoubtedly were due to sepsis, as the records examined ran back as far as the year 1872. Should critical evaluation be made of the methods, the comparative risks of the two procedures would more nearly approach each other if only the work of skilled operators in modern hospitals were taken on the one hand, as compared with the injection work that is being done in the average physician's office; for it is conceded by all to be an office procedure. It must be borne in mind that the cases reported by McPheeters were taken almost entirely from foreign clinics, the injections having been done under more or less ideal surroundings, mostly by expert technicians, as compared with much of the work that is being done at the present time under more or less handicapping conditions and unfavorable surroundings. The overwhelming assurance of the safety of this treatment as set forth in the foregoing statistics has been confirmed by much of the recent literature. Manufacturers of bandages, pharmaceuticals, etc., have culled from this literature paragraphs best suited to their purpose, and in the form of brochures, have freely supplied the profession with the knowledge of the requisite equipment and modus operandi of the treatment, and it has led to a more or less indiscriminate use of the intravenous treatment even by the cultists. One of the cases followed by death reported below is alleged to have been treated by an osteopath. The ease with which the treatment can be administered and the avidity with which it has been taken up by the profession, have brought words of warning from nearly every leading clinician engaged in the treatment; lest this valuable means of cure be cast into disrepute through individuals undertaking it without

Fig. 3. Sites for injections are marked with mercurochrome solution. With patient in prone position, limb is elevated to a right angle with body to empty veins by gravity. Rubber tubes are then applied and injections are made with leg lying on table, while assistant aids in forcing remaining blood into area to be injected.

Fig. 4. Fig. 5.

Fig. 4. J. P. W. Barber, aged fifty-five. Typical case of varicose veins, twenty years' standing. He was unable to work at his trade continuously, on account of pain. Veins were completely obliterated within a fortnight, since which time he has followed his vocation full time in comfort.

Fig. 5. Same case as Figure 4, nine months after treatment.

thoroughly familiarizing themselves with the principles underlying the causation and pathology, and particularly in neglecting the determining factors necessary to the proper selection of cases.

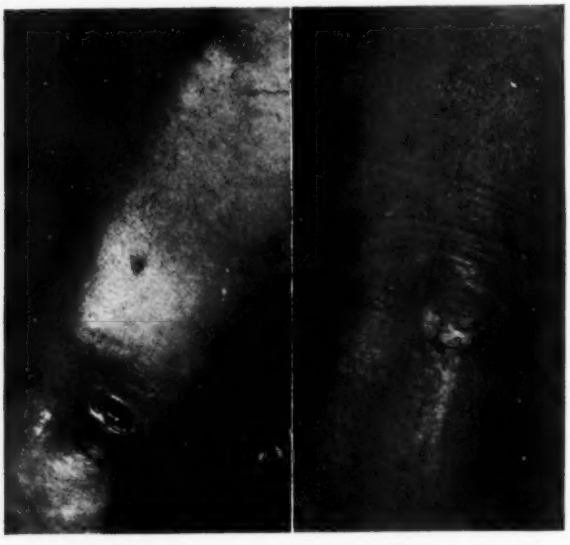

FIG. 6. FIG. 7.

FIG. 6. Mrs. F. M., aged forty-three. Phlegmasia albadolens fourteen years ago. Similar ulcer on same leg, inner aspect, directly opposite one shown. Not injected but treated with rubber sponges and A. C. E. bandages.

FIG. 7. Same case as Figure 6 four weeks after treatment was begun. She was advised to continue to wear the bandage. There has been no return of ulcers of two years' standing.

Of the complications following either the operative or injection method of treatment, embolism is the outstanding danger to be feared. Only 4 fatal cases of pulmonary embolism were reported in the 53,000 compiled by McPheeters and Rice. In his series of 15,000 cases, Prof. K. Linser is said never to have observed a fatal embolism. Thornhill[3] reported over 20,000 cases that had been injected by European surgeons, among them being Linser, 6000; Geneviere, 4000; Nobl, 3000; Douthwait, 2000; Jaugier, Sicard, and Forestier, more than 3000, none of whom reported fatalities from embolism. These statistics would indicate that embolism is a negligible factor. The fact, however, that 3 non-fatal cases of embolism occurred in my own practice, when I had treated less than 400 cases, in which not exceeding 2500 treatments were given, and that 4 deaths in various parts of Iowa were said to have occurred following the administration of the injection treatment, opens the question as to the accuracy of the common assertion that the injection method is entirely without danger.

Of the 4 deaths, 2 were verified by physicians in attendance on the cases as having died from pulmonary embolism. It must be admitted, however, that in but one case has it been possible to obtain an accurate history or report from the physicians who administered the treatment. In this case, the death unquestionably was due to embolism. Autopsy was made on none of the cases, but all the deaths followed within thirty days after the administration of the treatment, and 3 at least were reported to have suffered all the characteristic symptoms of pulmonary embolism, which leaves little doubt as to the cause of death in any of these cases. The fourth case brought to my attention is largely hear-say. My letter requesting information concerning the death, addressed to the doctor who is said to have treated the patient, was not answered. The fact that all the cases mentioned have come to my attention unsolicited and facts pertaining to the accidents have not been voluntarily forthcoming would indicate that doctors are unwilling to report the fatal accidents that have followed the treatment. These fatalities have prompted me to bring the question of embolism to the attention of the profession and to consider, also, some of the other complications more or less frequently encountered in the treatment.

During the early years of the treatment, when the stronger escharotic solutions, such as mercury salts and sodium carbonate, were used, sloughs were of common occurrence. If any of either of these solutions escaped outside the vein during the injection, a slough was inevitable. Consequently, they were early abandoned for sodium chloride and sodium salicylate, the

milder solutions. However, sodium chloride and sodium salicylate were frequently found to cause marked sloughs. Any of the escharotics thus far used will produce a more or less severe reaction if, during the process of injecting the vein, any of the solution finds its way into the subcutaneous tissues. Even the sugar solutions and sugar combinations now being used, if partly injected outside the vein, will result in a more or less severe reaction. Normal salt solution and distilled water are the only solutions that may be injected with impunity without incurring the risk of more or less destruction of the tissues. One of these should be injected freely into the area in sufficient amount to dilute the solution, should any of the escharotic be accidently injected outside the vein. Owing to the free mobility of the varicose vein, embedded as it is in the loose subcutaneous tissue, it is more difficult to puncture than the normal vein. In attempting the injection, the needle may transfix the vein, as evidenced by the column of blood showing in the syringe only when the needle is being withdrawn after puncturing the vein. When this accident happens, some surgeons advise removing the needle and injecting at another site; however, if one waits a few moments, until the vein contracts, and then injects slowly so that very little intravenous pressure is exerted, one may safely proceed without removing the needle. It is advisable to use the milder sugar solutions or combinations of sugar and soda salts until one has become proficient in the work. The sodium salts are much more effective than any of the sugar solutions and must often be resorted to in order to procure a permanent blocking of the veins. Sloughs, when they occur, should be excised at once or treated with Dakin's solution until the necrotic core is separated, after which adhesive strapping, to coapt the walls, should be resorted to. Excision of the slough should not be attempted outside of the operating room of a hospital.

One case of metastatic infection occurred in my practice in a woman fifty years of age. Several localized abscesses below the knee formed that required incision and drainage. An initial chill with a temperature of 104° followed eighteen hours after the injection of a 40 per cent solution of sodium salicylate. The patient made a complete recovery and most of the varicosities and the varicose ulcer were cured; but the patient was confined to the hospital for three weeks. I am at a loss to account for the origin of the infection. The injection was done in the operating room of the hospital where all patients were being treated at that time and were given the regular preoperative preparation and every precaution was taken for carrying out the established aseptic technique.

I am more than ever convinced of the importance of strict asepsis in carrying out this treatment. Particular attention should be given to preparing the sites for injection. This should include shaving the hair when necessary, scrubbing with soap and water, and finally with 70 per cent alcohol. The sites for the injections are marked with mercurochrome which also fortifies against the introduction of infection. Not until I had equipped a special office operating room, with all necessary accessories, and procured competent assistance, was I willing to undertake this work outside the hospital.

At Broadlawns City Hospital, where much of the work is being done, no patient is subjected to treatment until a complete physical examination has been made, and if ulcers are present, a Kahn or Wassermann blood examination is made. Trendelenburg and von Perthe's modification reactions are observed in all my cases, and if there is suspicion that the deep return circulation is not functioning, the patient is made to walk several blocks with the leg securely bandaged up to the knee. If, upon his return, no discomfort is felt, the treatment may be safely advised. If, on the other hand, discomfort and pain result, relieved by the removal of the bandage, the treatment should not be administered. In such a case the varicosities are compensatory.

Arteriovenous fistula of the lower extremity is found but rarely. The condition, however, must be borne in mind and not confounded with varicose veins of the ordinary type. But few cases, I believe, of the aneurysmal type of varicose vein are benefited by the injection treatment. Since the classic works of Reid[4] on arteriovenous communications and the widespread use of the injection treatment for varicose veins, much interest has been aroused in these circulatory malformations, and special search has been carried on in various clinics. Horton[5] reports 23 cases of congenital arteriovenous fistula of the extremities observed at the Mayo Clinic from June 28, 1929 to May 11, 1931. The following case (Figs. 1 and 2) is especially interesting.

H. R. McG., aged twenty, was referred to me by Doctor Lovejoy for varicose vein treatment of the right leg. The enlargement of the veins of the right lower extremity was noticed by his parents at the time he began to stand alone and walk, and they have continued to increase in number and size up to the present time. Many of the veins are of the cavernous variety, being large pockets filled with blood, 2 cm. or more in diameter. The veins of the dorsum of the foot are as large as one's little finger. Three toes show birth marks on the plantar surfaces and the skin on the external aspect of the thigh just above the knee shows a reddish purple flammeus, the size of one's hand, also present at birth. No bruits, thrills, or pulsations are perceptible anywhere along the affected extremity. Blood drawn from a vein at the elbow is distinctly darker in color than that taken from the enlarged veins of the affected leg. The limb is increased in circumference from one to 5 cm., over that of the left leg, which is normal in all respects. The length of the affected limb, however, is not increased. A roentgenogram of the heart indicates that there is no enlargement of that organ and the pulse is normal. In all other respects, he is physically almost perfect and has suffered but little inconvenience on account of the defect. By the use of large doses of escharotics we have obtained the closure of many of the veins below the knee. He is still under treatment.

Perivenitis, first described by Sicard, is a distressing complication that occasionally arises after an injection. It may involve the total length of the long saphenous vein, and is more apt to occur in very extensive and extremely large varicosities. In large, extensive varicosities, one should not undertake to close too large a group of veins at any one sitting, and the solution should be confined to a comparatively small area for a period of ten minutes, then rapidly drained out by elevating the leg. My 3 cases of pulmonary embolism were preceded by perivenitis, one of which was very marked. These 3 non-fatal cases of pulmonary embolism presented all the cardinal symptoms of embolism and there could be no doubt as to the correctness of the diagnosis. Some months ago in a personal interview, Dr. McPheeters informed me that he had never had a non-fatal embolism in his practice. Emboli not sufficiently large to occlude the pulmonary artery, therefore, must be regarded as infrequent; however, in view of my own experience, it must be conceded that the accident is not as rare as statistics would lead one to believe. It is my opinion that embolism, when it occurs, is the result of infection, since the clot resulting from injection, under normal condition, clings to the injured vein wall and is tough and tenacious, possessing no tendency whatever to break up as does the loose, friable, infected clot lying loosely within the vein.

The question naturally arises; what can be done to prevent embolism? It is evidently impossible to anticipate in every case conditions that will determine the formation of embolus. Painstaking effort, however, should always be made to obtain a history of any former circulatory disturbance, such as an attack of thrombophlebitis, phlegmasia albadolens, or thromboangiitis obliterans (Buerger's disease). The safety of injecting patients that have suffered from any of these conditions is very questionable indeed.

It is well known that recurrence from the thrombophlebitis may take place after

varying periods, up to three or more years; and the dormant infection may easily be aroused by the sudden insult to the vein produced by an injection, which would be the signal for the whole system of varicosed veins of that extremity to become involved, and their lumen filled with pathological clots. Some surgeons, however, believe it safe to inject such cases after a year.

While it is apparent that statistics are misleading and that the dangers attending the injection treatment are underestimated, I am none the less enthusiastic in my support of it, in properly selected cases. It is one of the safest procedures in surgical practice. The edema that sometimes follows the injection may excite the patient but it need not cause the surgeon any anxiety, provided the deep return circulation tests have shown these veins to be functioning normally. A 4 inch A. C. E. bandage should be used until the treatment is completed. This helps to overcome the swelling and the pain. It should be borne in mind that none of the escharotics used are clot-producing agents. Their contact with the intima produces an eschar and the clot is formed slowly long after the solution itself has been dissipated into the circulation. The cauterizing process takes place almost instantly and should be completed within two or three minutes, provided the vein has been emptied of most of its blood before the solution is thrown in. The success of the treatment, indeed, depends upon the completeness with which the vein is emptied of its blood and the care with which the solution is confined to a definite area. This may be done in various ways. I frequently use a $\frac{3}{16}$ inch, pure gum rubber tube drawn about the leg above and below the point where the puncture is to be made, while the extremity is held by an assistant at right angle to the trunk to empty the veins, with the patient in the prone position. (Fig. 3.)

It is no longer considered dangerous to inject varicosities of the pregnant woman or of diabetics. The pregnant woman, up to the sixth month, may be treated and relieved of much suffering during the latter weeks of pregnancy. Diabetics may be safely treated after a short course of insulin.

The permanency of the injection treatment was an interesting and vital question for some years after the treatment was first introduced, more than ten years ago. This question was recently discussed by Howard, Jackson and Mahon[6] and the startling statement made that there were 98 per cent of recurrences in their cases following a year or more. Except in the very early cases done for esthetic reasons, they advocate a return to the old method of excision, or excision and injection. Their statement of recurrences does not conform with my experience. Neither does it appear to be in accord with the accepted reports of clinicians, here or abroad. Indeed, I am not aware of a single failure, that is, a complete recurrence or recanalization of the veins treated by injection. It is true that quite a large percentage of patients return a few weeks after injection, with islands of varicosities here and there, mostly new veins, enlarged, that require attention; "mopping up process" as I have termed it. And then again, during the treatment one occasionally sees blue veins beneath the skin, apparently insignificant and of no importance, yet in a few months these may become enlarged varicosed veins. Neither of these conditions, in my opinion, should be classed as a recurrence or failure of the injection treatment. Apparently the San Francisco men have done this very thing.

Varicose veins are a progressive, degenerative process, and it is not possible always to say just when our cases have been completely treated. I have, therefore, always insisted on patients returning for observation at intervals for a year or more after treatment. Dr. H. O. McPheeters, in a personal communication, likens the varicose veins state to decayed teeth. He says, "A patient may have all his teeth filled, but decay will continue and the patient will have more decayed teeth

at the end of two years, even though all his teeth were in good condition previously." Usually these veins are readily obliterated by repeating the injection, using one of the standard solutions. Almost without exception, our patients are happy and satisfied with the results obtained, even though they do come back at the end of six months or a year with a few scattered loops of veins. The simple matter of injecting these veins, even though a third series of injections is required, is preferable to excision with all its uncertainties and attendant dangers, to say nothing of the time lost and the additional hospital expenses incurred.

CONCLUSIONS AND SUMMARY

The injection treatment has superseded all other measures and it is considered to be one of the safest of all surgical procedures. The danger of embolism, however, is undoubtedly underestimated and is to be reckoned with. This accident should be reduced to a minimum by a familiarity with the conditions underlying the diseased processes, including the etiology and pathology, and one should be prepared to carry out and interpret all the necessary tests essential to proper selection of cases.

There is no one ideal solution in use that is always effective or fool-proof. Should a slough result, I prefer to treat it conservatively, bringing the walls together with adhesive strips after the separation of the necrotic core. Radical excision of the slough should be done only in a hospital operating room.

A complete physical examination of the patient and careful preparation of the limb is essential before any injection is attempted. At the present time, however, we know of no infallible means of preventing certain serious reactions and even grave disasters that occasionally follow the treatment.

Recanalization of injected veins may occur and varicosities may develop from apparently normal veins after injection and will require treatment. All patients, therefore, should be kept under observation for a year or longer.

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*Continued from p. 440.

THE PRESENT DAY STATUS OF ANESTHETIC AGENTS*

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AN investigation into the status of the various anesthetic agents must, of necessity, include a study of their actions on bodily structures and functions as well as a study of the explosiveness, controllability, and other characteristics peculiar to the agents themselves which may benefit or harm the human mechanism.

ACTION OF THE MORE COMMON ANESTHETIC AGENTS ON BODY STRUCTURES

CARDIOVASCULAR SYSTEM: Severe interference with the cardiovascular system is probably the most important cause of death immediately following operation. The term "surgical shock" is applied to that combination of symptoms manifested by a severe lowering of the blood pressure, a narrowing of the pulse pressure and a great increase in pulse rate. Any agent which would alter the blood pressure and pulse rate picture in this direction, if prolonged, may be said to be conducive to surgical shock.

Ether, because of its cardiac stimulation in good risk patients, produces an increase in the pulse rate associated with a corresponding rise in the blood pressure. If long continued, especially in poor risk patients, the pulse rate will remain high and the blood pressure fall.

A nitrous oxide induction is usually marked by an increase in pulse rate associated with a rise in blood pressure a little greater than the rise in pulse rate would seem to warrant. This latter is attributed, by some, to a so-called "vascular spasm."

Ethylene occasions very much the same response as does nitrous oxide. The pulse rate climbs a little less high than under nitrous oxide. The average increase in systolic pressure is about 14.1 per cent and the pulse pressure about 31.4 per cent above the previous normal.[9]

The barbiturates, as a group, cause a moderate fall in blood pressure and an increase in pulse rate. This action, however, is transitory.[55] The fall in blood pressure under sodium amytal has been variously reported as between 15–30 mm. Hg,[70] 32 mm.[76] and 40–60 mm.[24] There exists the report of a case where the pressure fell from 210 to 60 mm. Hg.[24] Falls in blood pressure occurring under pernocton are not as great. The author, in a series of pernocton anesthesias, concludes that the average fall is between 5–20 mm. Hg. There were no cases where the fall varied widely from this average.

Avertin (tribromethyl alcohol) anesthesia is usually associated with a fall in blood pressure between 10–20 mm. Hg.[39] There is associated no, or at the most a very slight, increase in pulse rate. This fall in blood pressure is temporary.

Regional anesthesia,* unassociated with the use of epinephrine in the anesthetic solution, does not alter the blood pressure-pulse rate picture per se. Associated with epinephrine there results a change responsible to this solution.

Spinal anesthesia presents a change in the blood pressure and pulse rate that no other agent produces. The fall in blood pressure is rapid and lasts throughout the duration of the anesthesia. The pulse rate falls considerably but in 80 per cent of the cases maintains a normal relationship to the systolic and diastolic pressures.[93] This

* In the strict interpretation, regional anesthesia embraces spinal anesthesia, but since spinal anesthesia presents characteristics peculiar to itself it will be considered separately in this paper.

* Submitted for publication October 16, 1931.

fall in pulse rate associated with the fall in blood pressure is felt to act as a prophylactic to surgical shock as long as the normal blood pressure-pulse rate ratio is maintained.[93]

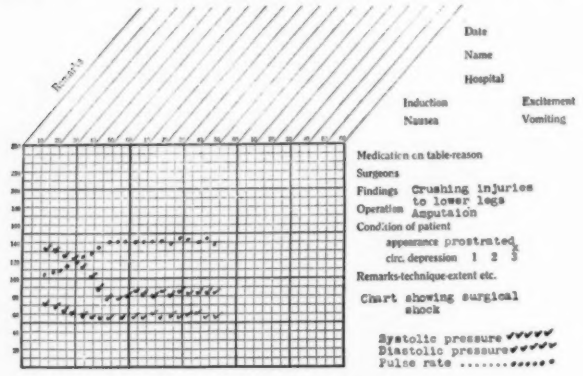

Fig. 1. Surgical shock.

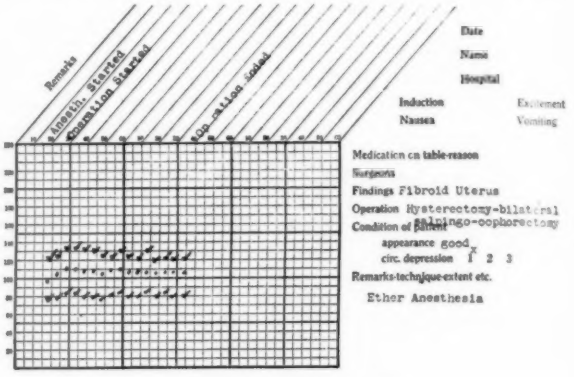

Fig 2. Ether anesthesia.

Pulmonary System: The induction of ether anesthesia is characterized by an increase in respiratory rate. In anesthetic doses the amplitude is increased. Overdose is responsible for a marked diminution in rate and amplitude. Locally, ether acts as an irritant and tends to produce postoperative pulmonary complications.

The gases, ethylene and nitrous oxide, are also responsible for an increase in rate and amplitude. This is probably due to the great amount of rebreathing usually employed. The rate and amplitude can be altered if the carbon dioxide in the expired air is filtered out by a soda lime container installed in the apparatus. Both these agents are administered with a minimum of oxygen. This is true particularly with nitrous oxide. Ethylene can be administered with a larger amount of oxygen than can nitrous oxide. These gases have no direct irritant action on pulmonary mucosa.

A diminution in the rate and amplitude of respiration is always present in anesthesia resulting from barbituric acid derivatives. This respiratory depression is probably the result of action directly on the central nervous system.[15,84,115] The extreme quiet which follows the administration of a barbituric acid derivative is reported as increasing the likelihood of postoperative pneumonia.[16]

Theoretically, this may be so; but no figures have been advanced to substantiate this statement. If it were true, administration of carbon dioxide-oxygen mixtures and frequent changing of the patient's position would obviate it. A shorter acting barbiturate would be indicated in a case where pulmonary complications are to be feared in favor of a longer acting one, as sodium amytal. Overdose of barbiturates may be followed by pulmonary edema.

A moderate amount of respiratory depression exists under avertin anesthesia. This respiratory depression is unassociated with cyanosis or pallor. The respiratory mechanism responds readily to carbon dioxide-oxygen mixtures.

The use of cocaine, novocaine or allied agents in peripheral nerve block is unaccompanied by any marked change in respiration. Overdosage, accidental intravenous injection or idiosyncrasy to the agent may be followed by acute intoxication. This manifests itself by a convulsive seizure including the musculature of the respiratory mechanism. Spasm of the respiratory muscles interferes with satisfactory respiration. If the attack is severe or prolonged death results from asphyxia.

Spinal anesthesia results in a definite and great respiratory depression. A decrease in rate and amplitude is present. This is associated with no cyanosis but pallor may occur. The depression is the result of the predominating influence of the vagi over the paralyzed accelerator sympathetic nerves.

Liver: Ether has a marked depressive action on the liver. It has been shown[90] that a two-hour ether anesthesia results in a dye

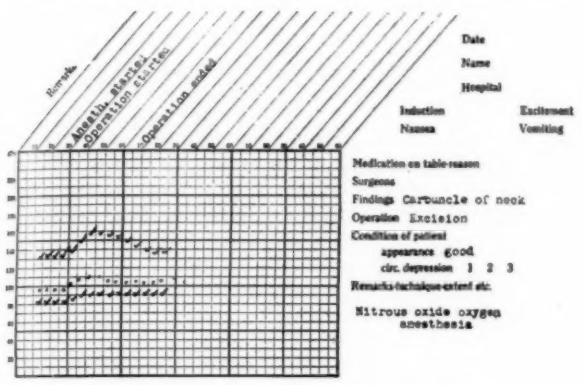

Fig. 3. Nitrous oxide oxygen anesthesia.

retention of 14 per cent. It is responsible for marked tissue change in this structure.[103,121]

The gases in the presence of large amounts of oxygen (17–25 per cent) produce no liver changes. The administration of the gases associated with anoxemia produces liver disturbance.[90] Ethylene, however, is responsible for less damage than is nitrous oxide.

The barbiturates have no deleterious action on liver function and produce no tissue changes in this structure.[6]

The damage to liver function under avertin anesthesia is negligible and compares favorably with the barbiturates.[6,8] Avertin is decomposed in the liver.[31] Overdose, because of this, may result in liver damage.

Regional anesthesia exerts no toxic action on this structure[31] in spite of the fact that the agents used for regional anesthesia are broken down in the liver.

Chloroform, like ethyl chloride, exerts a marked toxic action on the liver. Evidence is indisputable that chloroform poisoning is synonymous with chloroform anesthesia.[90]

Kidneys: Deep ether anesthesia markedly inhibits kidney function and may produce tissue changes in this organ.[103,121]

Ethylene is responsible for no kidney damage.[9] The same holds true for nitrous oxide.

The barbituric acid derivatives are excreted through the kidneys. They have no detrimental effect on this organ, however.[55] Enge and Hoffman[19] feel that sodium amytal is responsible for an actual and relative depression of urinary output. Phenolsulphonphthalein studies suggest that this is probably not due to a depression of glomerular activity but to a vasomotor failure to remove fluids from the body tissues.

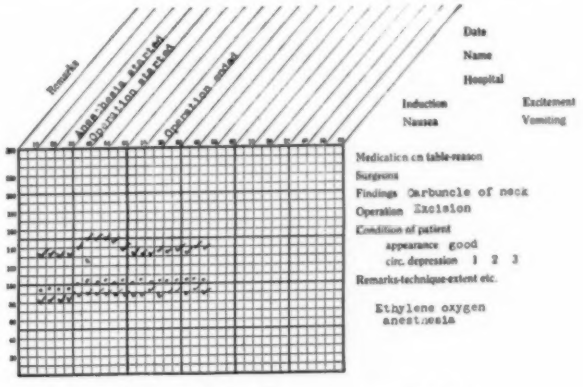

Fig. 4. Ethylene oxygen anesthesia.

Kidney function is more depressed with avertin than by the barbiturates.[6] This depression is transient and fully disappears in four to six hours.[8]

Regional anesthesia has no deleterious action on kidney structure or function. Regional anesthesia involving the sympathetic fibers to the kidney as in paravertebral block or spinal anesthesia is associated with an increase in urinary output.

Blood: A marked leucocytic reaction occurs after ether anesthesia. This reaction is much less marked after regional anesthesia.[27]

Blood Sugar: The hyperglycemia associated with anesthesia has been variously interpreted as either the result of diminution in sugar metabolism or due to an increase in glycogenolysis, that is, an increase in the rate at which glycogen in the liver is converted into sugar and given off into the blood. Estes and Burge[21] conclude that this increase in blood sugar is due to a decrease in sugar metabolism.

Whatever this hyperglycemia is due to there is no doubt that an anesthetic agent which seriously interferes with carbohydrate metabolism is contraindicated in several important pathological conditions associated with surgery.

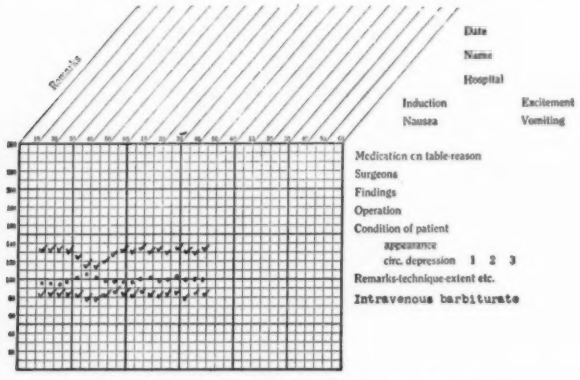

FIG. 5. Intravenous barbiturate medication.

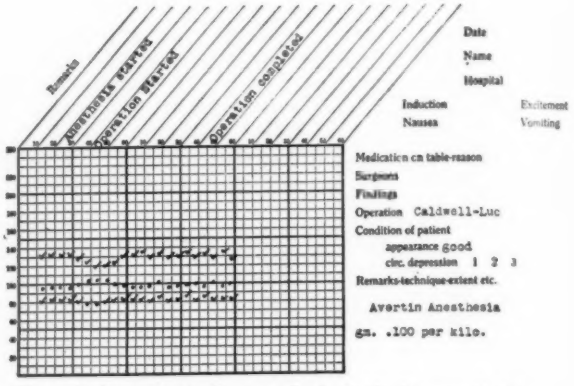

FIG. 6. Avertin (tribromethyl alcohol) anesthesia.

There exists a close relationship between the rise in blood sugar and general anesthesia.[79] Ether perhaps is the greatest offender in this regard. The rise in blood sugar under ether anesthesia far exceeds that under regional or spinal anesthesia.[79,93] There exists, under ether, an average increase of 27 per cent six hours after operation and 18 per cent at the end of twenty-four hours.[93]

Nitrous oxide has no effect on sugar utilization.[11]

Ethylene anesthesia is associated with an increase in blood sugar.[106] This increase is variously reported as 45.3 per cent[9] immediately after anesthesia and by another[109] as 29 per cent above normal. The increase in blood sugar under ether anesthesia is reported as being 46 per cent greater than that under ethylene anesthesia.[11]

The barbiturates are also followed by a hyperglycemia.[46,110] The increase reaches a maximum in one to two hours and returns to normal in six to twenty hours.[116]

The hyperglycemia associated with avertin anesthesia is but very little above the normal limits.

The use of a solution of novocaine without epinephrine in field or peripheral nerve block is unassociated with changes in blood sugar. If epinephrine is employed any change in blood sugar is the result of its action.

Spinal anesthesia is associated with an increase in blood sugar considerably less than that which occurs under inhalation anesthesia. The increase under spinal anesthesia in a series of cases[93] amounted to 5.4 per cent at the end of six hours and 5 per cent at the end of twenty-four.

BLOOD UREA: An increase in blood urea is referable to accumulation due to defective elimination through the kidneys.[108] Agents which result in an increase in blood urea do so as the result of kidney irritation and would be contraindicated where this is to be feared.

Ether causes an increase in blood urea of 28 per cent six hours after operation. The increase continues and at the end of twenty-four hours mounts to 69 per cent.[93]

The gases are associated with an increase in blood urea. In the case of ethylene the increase begins immediately after operation and continues until at the end of twenty-four hours the increase amounts to 18.7 per cent over the preoperative normal.[9]

Derivatives of barbituric acid cause no change in the concentration of blood urea.[30]

Avertin, because of its mild kidney depression, is probably also followed by some degree of accumulation of blood urea though no available reports confirm or deny this. This accumulation must, of necessity, be small since the kidney irritation is but transient.

Spinal anesthesia produces no increase in blood urea at the end of six hours after operation. Twenty-four hours after operation the increase amounts to 24 per cent.[93]

Carbon Dioxide Combining Power: The ability of the blood plasma to bind carbon dioxide offers what is probably the most reliable means of detecting acidosis and measuring its degree.[108] The value of an agent preventing acidosis is inversely proportional to the extent of change in the carbon dioxide combining power and the blood sugar produced.

Ether causes a decrease of 10 c.c. per 100 c.c. of blood plasma six hours postoperatively. Twenty-four hours postoperatively this decrease amounts to 3 c.c.[93]

Ethylene results in a moderate decrease in alkali reserve of the blood.[9] The same is true of nitrous oxide.

Barbituric acid derivatives are responsible for no change in the carbon dioxide combining power.[12,122] The same holds true for avertin. Bourne et al.[6] feel that neither amytal nor avertin affects the carbon dioxide combining power of the blood providing good color is maintained.

Neither novocaine nor agents allied to it have any marked action on the carbon dioxide combining power. In a series of cases operated upon under spinal anesthesia in which such studies were done[93] the carbon dioxide combining power decreased 7.8 c.c. at the end of six hours. At the end of the twenty-four hour period this decrease amounted to 3 c.c.

Musculature: Ether and chloroform in safe anesthetic dosage produce good relaxation of voluntary muscles. To obtain good relaxation for upper abdominal surgery under ether would be but to expose the patient to the harmful effects of deep ether anesthesia.[100]

Ether and chloroform, during surgical anesthesia, cause a marked loss of tonus amounting to almost complete inhibition of both rhythmic and peristaltic contractions in the stomach, small intestine and colon.[81] During the recovery period there occurs a return to normal.

Ethylene and nitrous oxide produce but slight relaxation of voluntary muscles. The relaxation produced by ethylene, however, is somewhat greater than that produced by nitrous oxide. Ethylene[81] produces usually no marked change in the muscular elements of the gastrointestinal tract. However, there sometimes occurs a slight increase in tonicity. Nitrous oxide[81] produces a marked increase in size of contraction of stomach, ileum and colon, probably due to anoxemia. On discontinuing the nitrous oxide there occurs promptly a very marked inhibition of activity in these three portions of the gastrointestinal tract.

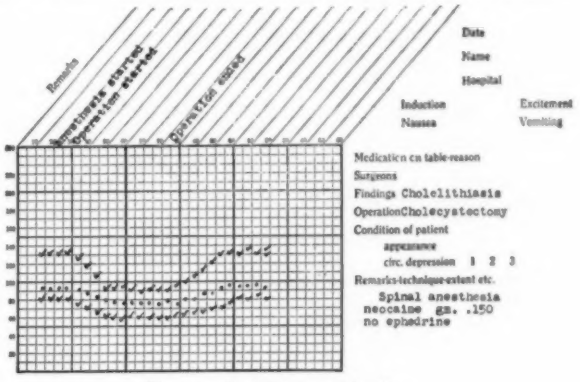

Fig. 7. Spinal anesthesia.

All inhalation anesthetics posesss an inhibitor action on uterine contractions in the following order, with chloroform the greatest offender: chloroform, ether, nitrous oxide, ethylene.[91]

The administration of a derivative of barbituric acid has no effect on uterine contraction nor does it alter its response to the "oxytoxic" principle of the pituitary gland.[44,122] Relaxation of voluntary muscle is fair and is proportional to the dose.

Avertin results in a degree of relaxation of voluntary muscles between that of the barbiturates and ether. It has no action on uterine contractions.[88]

The placing of a solution of novocaine about peripheral nerves results in but moderate relaxation. The action of novocaine on nerve roots within the subarachnoid space, as in spinal anesthesia, results in the most profound type of relaxation. Spinal anesthesia causes a paralysis

of the inhibitory sympathetic fibers to the gastrointestinal tract and allows the accelerative action of the vagi to pre-

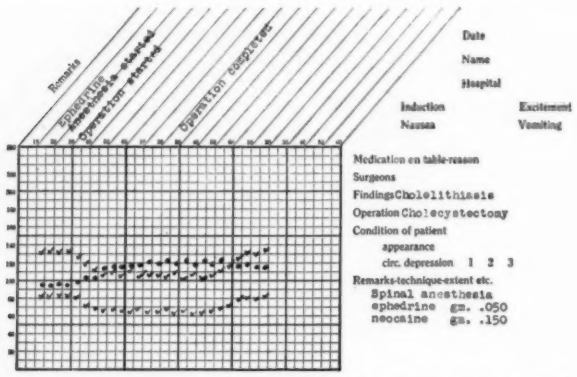

FIG. 8. Spinal anesthesia preceded by administration of ephedrine.

dominate, resulting in hyperperistalsis. It has no depressive action on uterine musculature.

CENTRAL NERVOUS SYSTEM: The inhalation anesthetics have no direct untoward action on the central nervous system. The administration of barbiturates in heavy doses and over a period of days may result in some degeneration of brain tissue. The barbiturates cause profound sleep but offer no protection against surgical shock to the nervous system.[75] Neither avertin nor the local anesthetic agents cause any damage to nerve structure. Regional anesthesia in all its forms offers the best known protection against surgical shock to the nervous system, because of the interruption of afferent stimuli that it produces.

CONTROLLABILITY

The large amount of gas-exchanging mucosa in the pulmonary system plus the ability to control respirations by the use of carbon dioxide-oxygen mixtures make the inhalation anesthetics subject to most exact control. Of the inhalation anesthetic agents ether is the least controllable since its action is not as rapid as that of nitrous-oxide or ethylene.

The use of avertin necessitates the use of a predetermined dose. Once given, any untoward symptoms cannot be relieved by washing out the rectum. Sodium amytal calls for the administration of a previously calculated dose. Pernocton, a quicker act-

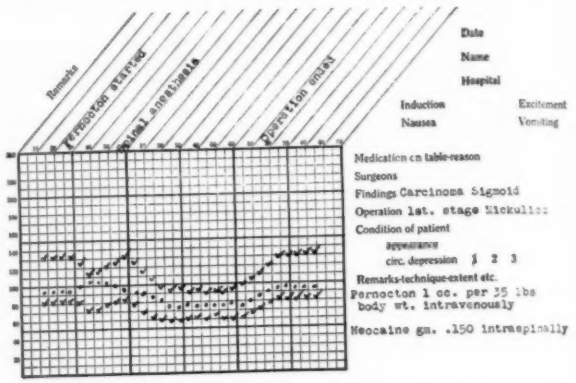

FIG. 9. Spinal anesthesia preceded by intravenous administration of barbiturate.

ing barbiturate, can be more readily controlled than sodium amytal, since, at the first sign of sleep, administration of the agent can be interrupted. Once administered the barbiturates cannot be removed. The effect of caffeine on narcosis from barbituric acid derivatives is antagonistic, tending to interrupt the sleep. The recovery time from barbiturates is markedly shortened by diuresis and the use of dextrose solutions intravenously.[57,59,94] The effects of spinal anesthesia last as long as the novocaine action is present on the nerves in the subarachnoid space. Once administered, the novocaine in the spinal canal can not be removed.

EXPLOSIVENESS

Of the anesthetic agents ether, ethylene, ethyl chloride, and acetylene are explosive. Acetylene is the most explosive. Because of this it has not been employed to any great extent anywhere other than in Germany. Mixtures of ether or ethylene with air or oxygen, in certain concentrations, are explosive. The number of ether air explosions are relatively small compared with the number of ether anesthesias administered.[119]

The administration of an explosive anesthetic through a gas machine increases the hazard in this direction. Electric

sparks resulting from the reestablishment of electrical equilibrium after charges have been accumulated on some insulated

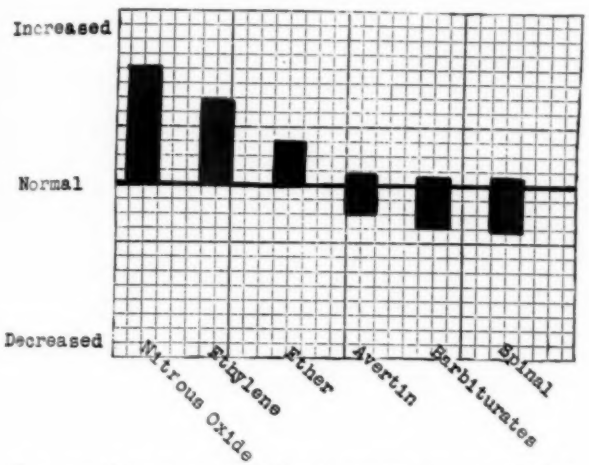

Fig. 10. Action of anesthetic agents on respiration.

part of the apparatus, usually as a result of friction, are the causes of explosions most important and most difficult to prevent.

The range of explosiveness of ethylene mixtures ranges from 4–22 per cent. That of ether extends from 2–50 per cent. The range of explosibility from ether is the greater of the two. Explosions occur more often with ether than with ethylene.[43] Statistics[93a] show an explosion in ethylene for every 42,000 cases. For ether the rate is 3 in 20,000 anesthesias.

Ethylene explosions are usually more violent and more fraught with danger than those occurring with ether. In spite of the danger of explosion with certain anesthetic agents the feeling exists that explosion is statistically the least of the hazards of anesthesia.[43]

LOCAL IRRITANT ACTION OF ANESTHETIC AGENTS

Ether is an irritant to the respiratory tract. It irritates and excites secretion from the glands lining the mucous membrane of the bronchial tree. It tends to produce postoperative pulmonary complications.[101] Neither nitrous oxide nor ethylene has any direct irritant action locally.

Of all the anesthetic agents avertin presents the greatest single danger as regards a locally irritant action. Avertin

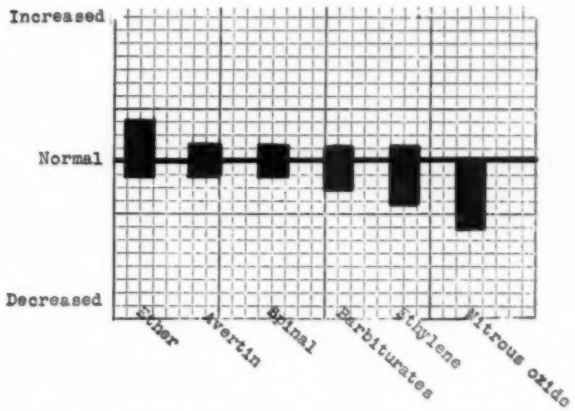

Fig. 11. Action of anesthetic agents on oxygen consumption.

fluid, as dispensed by the manufacturers, is a solution of tribromethyl-alcohol in amylene hydrate. The solution is very unstable. In preparing a 3½ per cent solution for anesthesia the avertin fluid is added to distilled water at a temperature between 35 and 40°C. Above 40°C. hydrobromic acid is split off and dibromacetaldehyde is produced according to the following chemical equation:

$$CBr_3.CH_2OH - HBr = CBr_2{:}CHOH = CHBr_2.CHO$$

The presence of dibromacetaldehyde even in small amounts causes injury to intestinal mucosa. Severe sloughing may result. The obligatory test employing a 1:1000 congo red solution to determine the reaction of the solution will readily determine the presence of this highly irritating compound.

The solutions of barbituric acid derivatives for intravenous use are highly alkaline (pH 9.8) and hypertonic. It is important that these solutions be administered slowly so as to allow the buffer action of the blood to compensate for the differences in solutions.

Novocaine exerts no locally irritant action. The increase in popularity of regional anesthesia coupled with the desire for a longer acting local anesthetic agent

has resulted in the production of nupercaine (percain). The toxicity of nupercaine is high, even exceeding cocaine in this respect.[29,67] Solutions of this drug even in 1:2000 dilution cause an initial vascular relaxation in the vessels in the neighborhood of injection followed by a constriction.[67] This has frequently resulted in troublesome hyperemia and larger amounts of epinephrine in the solution are necessary than when employing novocaine.

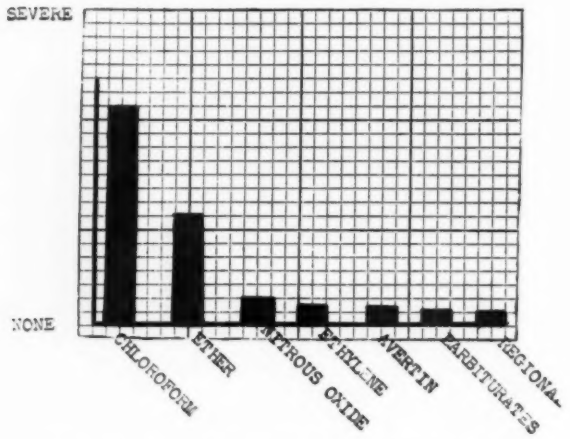

FIG. 12. Action of anesthetic agents on liver.

Pantocaine, another new and long acting anesthetic for local anesthesia, is at present being used in Germany. Among the advantages claimed for it are its comparatively low toxicity and prolonged effect.

ANTAGONISTIC ACTION TO POISONING FROM LOCAL ANESTHETIC AGENTS

Death from novocaine or cocaine is the result of either an overdose, intravenous administration or an idiosyncrasy. A reaction is manifested by a convulsiform attack. This seizure if severe and if it involves the respiratory muscles may result in death.

Agents with ability to relax the voluntary muscles have been tried with the hope that relief of the seizure will follow. Tatum et al.[107] confirm the results of others that ether, morphine, chloral hydrate and atropine cannot be regarded as satisfactory antidotes for cocaine poisoning.

Hofvendahl[47,48,49] was the first to call attention to the protection which a derivative of barbituric acid affords an animal or patient against the toxic effects of a local anesthetic agent. She demonstrated that an animal given what would ordinarily be a lethal dose of cocaine, would be prevented from death by subcutaneous administration of a derivative of barbituric acid. As a result of her work she recommends that a barbiturate be given to a patient suffering from acute cocaine poisoning.

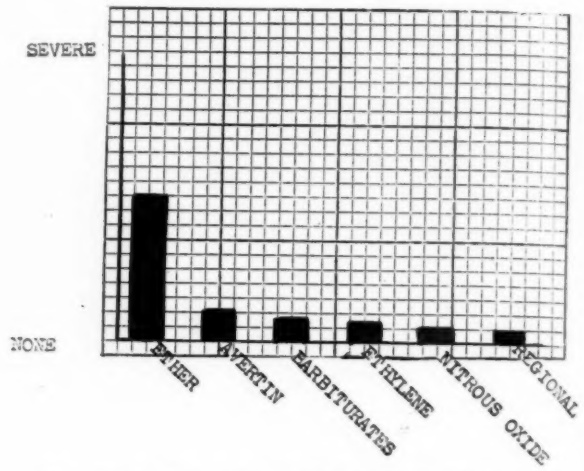

FIG. 13. Action of anesthetic agents on kidneys.

Tatum[106] as did Mendola[78] showed also that the barbiturates act antagonistically to the convulsive effect of novocaine. This work has been repeatedly confirmed.[38,62,73,74,85] The antagonism of barbiturates for the local anesthetic agents is due to antispasmodic effect.[52]

THERAPEUTIC VALUE OF ANESTHETIC AGENTS

Ether because of its ability to relax musculature has been employed in many diseases marked by muscular spasm or rigidity. Notable among the diseases treated by this agent is whooping cough.[83,105] The value of ether in whooping cough is still not definitely decided.

The gases nitrous oxide and ethylene have found but small use in the field of therapeutics.

The barbiturates because of their antispasmodic action have not only found a

field of usefulness in the prevention and treatment of acute intoxication from local anesthetic agents but in other fields as

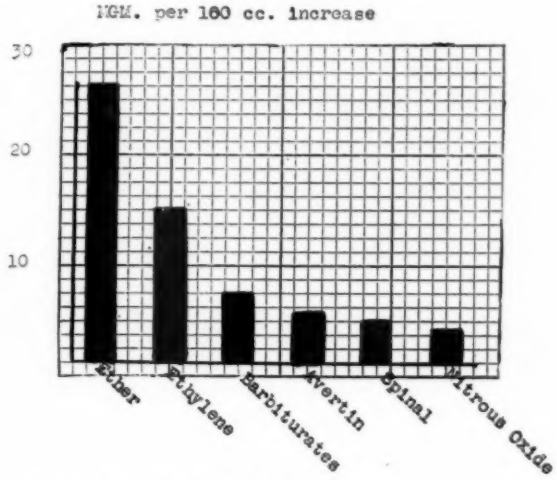

Fig. 14. Action of anesthetic agents on blood sugar.

well. Their value as antispasmodics is unquestioned in the treatment of convulsions from rabies, meningitis,[69] tetanus, strychnine poisoning, and eclampsia. Because of their hypnotic and sedative properties they have found a field of usefulness in the treatment of:[2,32]

1. Manic phase of manic depressive psychosis.
2. Catatonic schizophrenia.
3. Psychoneuroses.
4. Idiopathic epilepsy.
5. In cases attended by marked excitement with severe insomnia.

Avertin has been employed with satisfactory results in many of the conditions in which the barbiturates are of value. Among the many conditions treated by the former are tetanus,[58,61,80] phrenic exeresis,[36] chorea[117] and the excitement stages encountered in psychiatric diseases.[4]

The ability of the exploring needle to localize nerves carrying pain stimuli followed by the injection of a solution which will more or less permanently interfere with the passage of these stimuli has extended the value of regional anesthesia into the treatment of such conditions as trigeminal neuralgia, intercostal neuralgia, sciatica, tuberculous laryngitis and angina pectoris. The interruption of efferent sympathetic impulses is of great value in the treatment of circulatory diseases of the

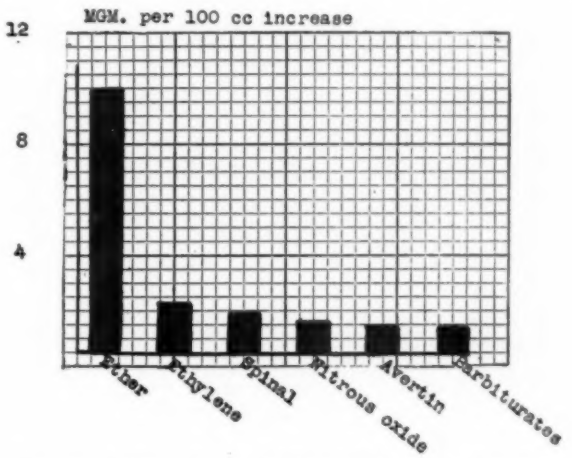

Fig. 15. Action of anesthetic agents on blood urea.

extremities as endarteritis obliterans, Raynaud's disease and trophic ulcers.

Spinal and splanchnic analgesia both occasion a marked hyperperistalsis. Thus they are of great value in the treatment of paralytic ileus. Spinal anesthesia is of value in the treatment of eclampsia.[86,104]

AGENTS

Chloroform: Chloroform possesses severe toxic action on the liver, kidneys and heart. Since there are other anesthetic agents which possess all of its advantages and less of its dangerous qualities chloroform does not merit a place in modern anesthesia.

Ether: Ether, today, is still the safest anesthetic agent in unskilled hands. It is readily controllable and produces good muscular relaxation. Its administration is associated with irritation to the pulmonary mucosa and tends to produce postoperative pulmonary complications. Its action on the blood sugar, carbohydrate metabolism and carbon dioxide combining power is marked. This, plus the loss of fluid coexistent with ether anesthesia, and the postoperative nausea and vomiting predisposes to acidosis. It depresses kidney and liver function and often produces tissue changes in these structures. Ether

is inflamable and has resulted in explosions in combinations with either air or oxygen.

Ether is contraindicated in all forms of

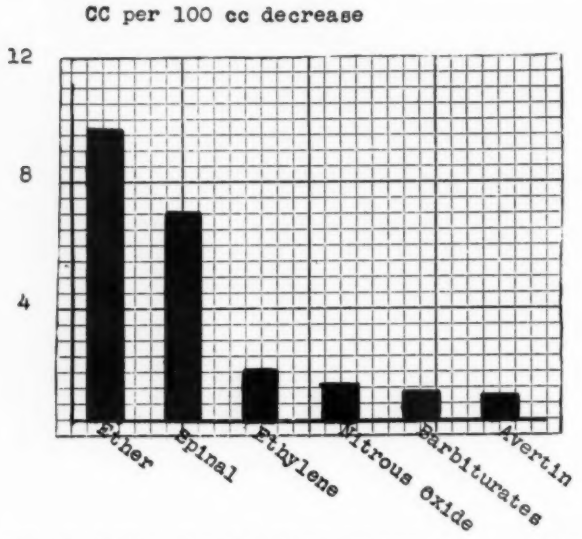

Fig. 16. Action of anesthetic agents on carbon dioxide combining power.

pulmonary disease. In vascular diseases, particularly when a sudden rise in blood pressure is to be feared, inhalation anesthesia is to be avoided, if possible. Ether is also contraindicated in diseases of the liver and kidneys. It should be avoided in diseases associated with deficient carbohydrate metabolism.

Ether is indicated in the absence of the above-mentioned diseases when a general anesthetic is desired and good relaxation needed.

Ethyl Chloride: Ethyl chloride has a toxic action midway between that of chloroform and ether. It is a powerful anesthetic and is rapid in its action. It has but a limited field of usefulness in modern anesthesia. It is usually employed for short anesthesias where nitrous oxide or ethylene are not advisable or the apparatus not at hand.

Nitrous Oxide: Nitrous oxide is comfortable to take. It is probably the most controllable anesthetic agent we have at this date. It exerts no toxic action on the body of itself. It is, however, associated with varying degrees of anoxemia which, in turn, may result harmfully. Nitrous oxide causes a marked rise in blood pressure which contraindicates its use in arteriosclerosis with hypertension. It is

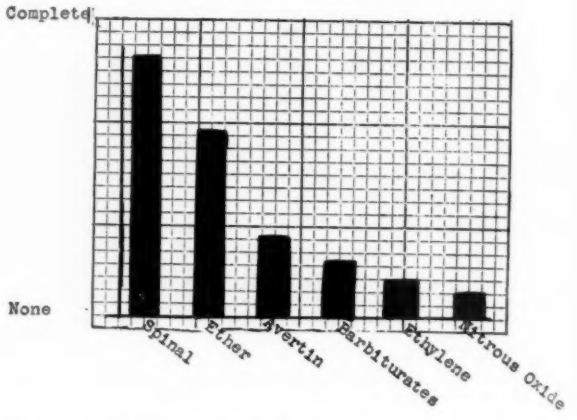

Fig. 17. Action of anesthetic agents on voluntary muscles.

non-inflamable and causes less nausea and vomiting than any of the other inhalation anesthetics. It does not produce good relaxation and is of value only in those conditions requiring general anesthesia with a minimum of relaxation.

Ethylene: Ethylene is the most dangerously explosive anesthetic agent at our command with acetylene probably the only exception. In spite of its extreme explosiveness it has caused less explosions than ether. It is not as comfortable to take as nitrous oxide. It stands next to regional and spinal anesthesia in freedom from toxic action. In this respect it has no pronounced advantage over nitrous oxide. Its main advantages over nitrous oxide are that it can be given with greater amounts of oxygen and produces a better degree of relaxation. Nausea and vomiting occur more frequently than after nitrous oxide. Ethylene should be administered only in the presence of adequate precautions to prevent explosion. It is of value when general anesthesia is desired and only moderate relaxation needed.

Barbiturates: The barbituric acid derivatives are comfortable to take. They have no toxic action on the vital structures or functions. Their hypnotic action make them valuable as basal narcotics and

result in a great diminution in the amount of the secondary agent. These derivatives may be used as a preanesthetic agent with

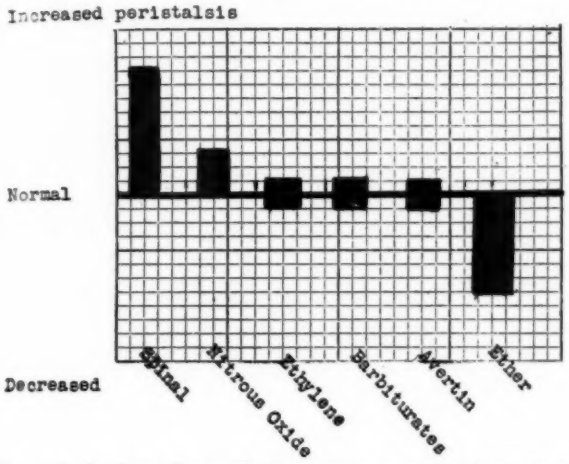

Fig. 18. Action of anesthetic agents on gastrointestinal musculature.

any of the general or regional methods. Their value in the prophylaxis and treatment of novocaine or cocaine poisoning makes them desirable in conjunction with regional or spinal anesthesia. Patients require less morphia and suffer less nausea and vomiting postoperatively. Their use as a preanesthetic agent is accompanied by a higher degree of vital reserve than when local or general anesthesia is used alone.[54]

In large doses there exists the possibility of pulmonary complications. Their action in the arteriosclerotic and hypertensive patient is often unsatisfactory. They are contraindicated in patients with unstable cardiovascular systems. The fall in blood pressure that they occasion makes them contraindicated in the presence of surgical shock. Their action is often followed by a period of excitement varying in length and intensity depending on the derivative used.

Of the two most popularly used barbiturates, pernocton impresses the author as being the more valuable in the majority of cases. Pernocton is a more stable solution and has twice the strength of sodium amytal.[77] It is relatively less toxic than the other barbiturates since it undergoes a more rapid decomposition in the body.[25] Its action is not as prolonged and there is less possibility of postoperative pulmonary complications since the duration of sleep is

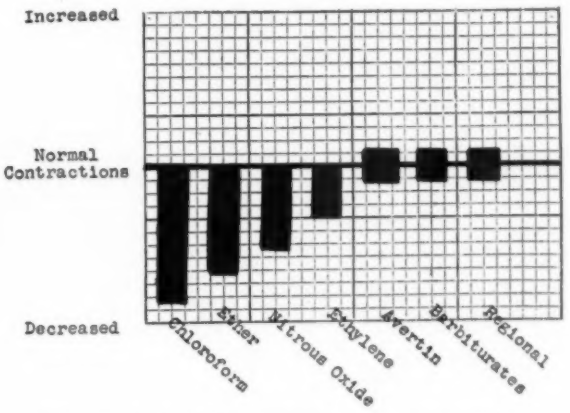

Fig. 19. Action of anesthetic agents on uterine musculature.

comparatively short. There occurs less excitement, laryngospasm and cyanosis associated with its use than is true of the other barbiturates.

There are many water soluble barbiturates recommended for intravenous medication. One cannot assume that the actions of closely related barbituric acid derivatives are identical but it is safe to conclude that they are analogous and comparable to a degree.[54]

Avertin: Of all the anesthetic agents, avertin produces the most pleasant and calm induction. Distress, nausea and vomiting are absent in the recovery period. There exists no stage of excitement as occurs in the use of barbituric acid derivatives. The period of amnesia is prolonged. The extent of respiratory depression is not as marked as with the barbiturates. As a basal narcotic it results in the lessening of the secondary anesthetic agent. Nitrous oxide can be administered with large amounts of oxygen and a fair grade of relaxation obtained. Its use is followed by no pulmonary or cardiac complications attributable to the agent.

Its greatest value is in prolonged operations about the head and neck. Particularly is this true when electrosurgery is employed. The author employing a method

of fractional administration, soon to be reported, finds it very seldom necessary to administer a secondary anesthetic in using

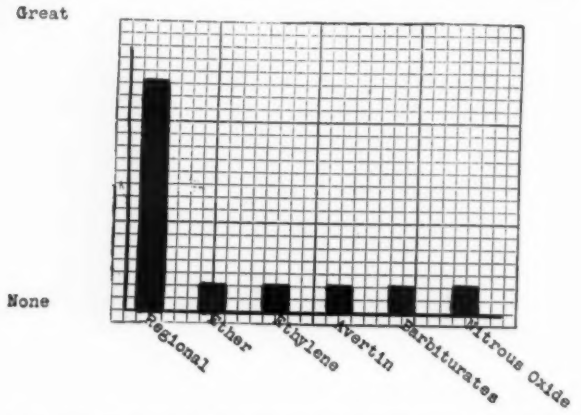

Fig. 20. Extent of protection offered central nervous system against surgical shock.

avertin for head surgery in dosage not exceeding gm. 0.12 per kilogram of body weight.

The relaxation produced exceeds that of the barbiturates. It is of value in conjunction with all other anesthetic agents as a basal narcotic. It is indicated in cases of respiratory and renal disease when ether is employed to lessen the tissue irritation of the latter. Sise[98] feels it of great value in long orthopedic operations. It has been employed with great satisfaction in thyroidectomy, thoracic operations, sinus surgery and obstetrics. Its value in the treatment of eclampsia, tetanus and excitement stages of mental diseases is great. The relative merits between avertin and the barbiturates in this latter field have never been decided. The author leans towards the barbiturates feeling that they are probably of greater value as therapeutic agents.

Avertin possesses two great disadvantages:

1. As a result of its unstable character, improper preparation of the solution may result in great damage to the rectal mucosa.

2. Because of its rapid absorption the patient may be flooded with a toxic dose that cannot be withdrawn if the dosage is not carefully calibrated.

Avertin is contraindicated in diseases of the rectum and colon. In patients suffering from advanced renal or liver disease this agent should not be employed.

Regional Anesthesia: Of all the anesthetic procedures, regional anesthesia offers the greatest protection to the central nervous system against surgical shock. Of the anesthetic agents, novocaine is considered the most safe and satisfactory in regard to toxic action on the body structures and functions. There exists but small chance of pulmonary, cardiac, liver or renal complications following its use. The relaxation obtained by peripheral nerve block is not as satisfactory as may be obtained by other methods.

In the field of therapeutics it is a valuable adjunct. The action of paracervical block in slowing the heart[7] makes the procedure valuable in operations on the toxic thyroid gland. Slowing cardiac action diminishes the occurrence and severity of thyroid crises.

The great danger always present in the administration of a local anesthetic agent is the acute intoxication which may occur as result of overdose, intravenous injection of the agent or idiosyncrasy. If a barbituric acid derivative is administered before the local procedure is begun this danger is considerably minimized. There exists the feeling among some anesthetists that large doses of barbiturates interfere with the efficiency of local anesthetic agents because of their antagonism.

Spinal Anesthesia: The introduction of novocaine in the subarachnoid space is followed by:

1. Sensory anesthesia
2. Motor paralysis
3. Fall in blood pressure
4. Decrease in respiratory rate and volume
5. Decrease in cardiac rate
6. Hyperperistalsis.

Sensory Anesthesia. The sensory anesthesia produced is absolute with the exception that complete loss of tactile sensation does not always occur. Many patients

object to the sensation produced by manipulation and interpret it as pain. This is a distinct disadvantage associated with spinal anesthesia. It may be easily overcome by sufficient preoperative medication.

Motor Paralysis. The relaxation that takes place far exceeds that under any other form of anesthesia. This great extent of relaxation facilitates operative procedures, particularly those in the upper abdomen, and results in a decrease in operating time. Difficult procedures can be carried out with less use of deep retraction and walling off pads, thus diminishing operative trauma.

Fall in Blood Pressure. The fall in blood pressure that occurs is proportional, to a degree, to the height of anesthesia obtained. This fall in blood pressure is the result of paralysis of the vasoconstrictor fibers to the splanchnic blood vessels. The fall in blood pressure is the greatest danger associated with spinal anesthesia. A severe fall in blood pressure may cause cerebral anemia and death may result. There are two methods employed to prevent this uptoward reaction:

1. Maintaining the blood pressure by vasoconstricting drugs such as adrenalin or ephedrine.
2. Preventing cerebral anemia by an adequate Trendelenburg position.

The action of adrenalin as a vasoconstricting agent is not of much value since its action is very short. Ephedrine is not primarily a vasoconstricting agent but raises the blood pressure through its cardiac stimulation.[93] Because of its cardiac acceleration its use is associated with an element of danger.[93]

The use of the Trendelenburg position is sufficient in itself to prevent anemia of the brain and should be employed in all cases of spinal anesthesia. The use of a viscid solution of novocaine of lighter specific gravity than spinal fluid has no definite advantages over a simple novocaine solution. Novocaine in glucose makes a solution heavier in specific gravity than spinal fluid and, as a result, calls for the employment of some degree of Fowler's position. Since the safest and most certain way to prevent cerebral anemia is by the use of the Trendelenburg position, any technique that calls for the use of any other position of the patient should not be employed.

Decrease in Respiratory Rate and Volume. Novocaine intraspinally causes paralysis of the accelerator fibers to the respiratory musculature and a decrease in respiratory rate and volume follows. This decrease is often associated with some degree of pallor

COMPOSITE CHART

	Pulmonary Irritation	Liver Irritation	Kidney Irritation	Blood Sugar	Blood Urea	Carbon Dioxide Combining Power	Relaxation of Voluntary Muscles	Peristalsis	Uterine Contractions	Protection to C.N.S. against Surg. Shock	Local Irritant Action	Antagonistic Action to Novocaine Poisoning	Loss of Consciousness
CHLOROFORM	++++	++++	++++	++++	++++	----	+++	----	----	0	++	0	+
ETHER	++++	++++	++++	++++	++++	----	+++	----	----	0	++++	0	+
NITROUS OXIDE	+	++	0	0	+	--	+	++	--	0	+	0	+
ETHYLENE	+	+	0	+++	++	--	++	+	-	0	+	0	+
BARBITURATES	0	0	+	++	+	-	++	0	0	0	+	++++	+
AVERTIN	0	+	+	+	+	-	++	0	0	0	+++*	0	+
REGIONAL	0	0	0	0	0	0	+	0	0	++++	0		0
SPINAL	0	0	0	+	+	-	++++	++++	0	++++	0		0

*Only if improperly prepared.

FIG. 21. Composite chart.

but never cyanosis. Respiration responds readily to carbon-dioxide oxygen mixtures. The feeling that spinal anesthesia may

Diseases Which Contraindicate Certain Anesthetic Agents	Chloroform	Ether	Nitrous Oxide	Ethylene	Barbiturates	Avertin	Regional	Spinal
Heart disease Compensated	+++	−	−	−	−	−	−	−
Non-compensated	++++	++	++	+	−	−	−	−
Hypertension	+++	++	+++	++	−	−	−	−
Hypotension	+++	++	+	+	+	+	−	+
Kidney disease	++++	++++	−	−	+	+	−	−
Liver disease	++++	++++	−	−	−	+	−	−
Hyperthyroid	++++	++	+	−	−	−	−	−
Diabetes	++++	+++	−	−	−	−	−	−
Resp. obstruction	++++	++++	+++	++	−	−	−	−
Shock Untreated	++++	++++	+	+	++	+	−	+
Treated	+++	++	−	−	−	−	−	−
Intestinal obstr. Curative operation	+++	++	+	+	−	−	−	−
Palliative operation	++++	+++	+	+	−	−	−	−
Pulmonary dis.	++++	++++	++	++	+	+	−	−

Indicated −
Contraindicated +

sufficiently depress respiration as to cause death has been thoroughly disproved by the excellent work of Koster and Kasman.[64]

Decrease in Cardiac Rate. The introduction of novocaine in the subarachnoid space results in paralysis of the accelerator sympathetic fibers to the heart and allows the depressor action of the vagus to predominate. This slow heart action is never the cause of untoward reactions and may be interpreted as a desirable symptom.[93]

Hyperperistalsis. The hyperperistalsis that occurs is the result of paralysis of the depressor fibers to the intestines. This hyperperistalsis is associated with a narrowing in the lumen of the gut. This narrowing in the lumen of the gut facilitates surgical procedures as the intestines fall back away from the wound rather than poke up into it as is true with inhalation anesthesia. This hyperperistalsis makes spinal anesthesia a valuable agent in cases of acute intestinal obstruction providing intestinal drainage is instituted.

The operative time in spinal anesthesia is limited usually to one hour although it sometimes extends to one and one-half hours. The administration of an inhalation anesthetic to a patient already under spinal anesthesia should be slow and careful. Nausea and vomiting sometimes occur during spinal anesthesia particularly during manipulation in the upper abdomen. Many patients object to being conscious during spinal anesthesia. The combination of intravenous administration of a barbituric acid derivative and spinal anesthesia is sometimes employed. Care must be taken to allow the fall in blood pressure that

occurs with barbiturate medication to return near normal before subjecting the patient to the fall in pressure that is so intimately associated with spinal anesthesia. The interval necessary is usually about twenty minutes (Fig. 9). The use of spinal anesthesia in patients with renal deficiency is valuable since spinal anesthesia is responsible for an increase in urine output.

Other Agents: *Acetylene.* Acetylene is an extremely explosive gas. It is used to some extent on the continent but as yet has made no marked appearance in this country.

Propylene. Propylene has a direct irritant action on heart muscle. It causes marked irregularities in cardiac action and therefore should not be used as an anesthetic agent.

Ethyl Alcohol. The use of alcohol in a glucose solution has been employed as an anesthetic agent with varying results. It is administered intravenously. Sufficient laboratory data on this agent are not available and not much work has been performed in this direction.

Cyclopropane. This gas is explosive in combination with small percentages of air or oxygen. The inability to manufacture constantly pure specimens has limited the use of this agent.

Chloral Hydrate. Chloral hydrate as an anesthetic agent to be given by rectum has been used in but a very limited number of cases and no laboratory studies have been made.

CONCLUSION

If a non-toxic, non-irritating, easily administered, safe, controllable agent constitutes the ideal anesthetic then we have today no agent which we could thus classify. Each anesthetic agent at our command has one or two unsatisfactory characteristics. The choice of the best anesthetic agent depends upon a knowledge of the action of the various anesthetics, a thorough understanding of the pathological processes present in the patient and the character of the operation proposed. The final choice of the agent or combination of agents should be those that would expose the patient to the least amount of harm and give him the greatest chance of getting well.

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EXPERIENCE WITH LUMBAR ANESTHESIA IN OBSTETRICS*

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ANESTHESIA, until less than fifty years ago, depended on the use of cerebral intoxicants; alcohol, mandragora and opium in ancient times, ether, chloroform, nitrous oxide and a variety of other volatile agents used by inhalation and by rectum since the middle of the nineteenth century. Only since the discovery of agents capable of application to peripheral neurons has the necessity of deadening the brain to obtain relief of pain been avoidable.

The application of anesthesia to patients in labor began shortly after the use of inhalation anesthesia in surgery, but has not kept step with it. The necessity for surgery is pathological; labor is physiological; the pain of surgery is calamity; that of parturition is normal life-experience. Not only do medical and popular imagination not respond so readily to the need for obstetric anesthesia, but tradition and even theological authority have repeatedly been strongly arrayed against its development. Even today, while surgical patients universally demand anesthesia for the most trivial operations, thousands of women endure the pain of childbirth, often of excruciating intensity, without any anesthetic relief.

Moreover, the problems concerned with obstetric anesthesia differ sharply from those of other types of surgery. There is general parallelism in the facts that obstetric operations are frequently indicated by conditions just as seriously pathological as those for which general surgical procedures are undertaken; that obstetric patients sometimes are poor physical risks by reason of toxemia and other intercurrent conditions which contribute to the hazards of general surgery; and that shock and hemorrhage are alike a jeopardy in both classes of work. But there is very significant divergence between general surgery and obstetrics, in the difference in length of anesthesia required, and in the fact that obstetrics nearly always involves two patients in one, as general surgery does only in the extremely rare instances of its application to joined monsters.

Labor involves many hours, stretching sometimes into days, whereas the most formidable and tedious operations of general surgery can hardly last more than three or four hours. Before efficient anesthesia was obtainable, surgeons shortened the time of their work by the cultivation of a deft speed which probably has no modern counterpart. And today, while speed per se is not a primary desideratum, a reasonable acceleration of delicately precise technique does much to obviate postoperative morbidity. No comparable means of shortening the time required for the normal, or safe operative evolution of parturition is at the disposal of the obstetrician.

Hence, while general surgery demands total anesthesia for its activities, the obstetrician must accept for his patients a partial relief only for the pangs of delivery.

The necessity for this acceptance of partial analgesia instead of full anesthesia depends on the deleterious effects on the woman's own vital processes of inordinately prolonged administration of intoxicating anesthetics and the even more direct and serious menace thereof to the survival and health of her child. Long since, therefore, the employment of anesthesia in obstetrics has determined itself into two phases; the use of analgesic agents or combinations for the relatively less severe suffering of the first stage and the early part of the second,

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and the supplementary employment of true anesthetics for the termination of the second stage, especially if that termination is operative.

Even used in this fashion, however, anesthetics depending on cerebral action involve in considerable degree the hazards previously pointed out, especially to the baby, so that anesthetic methods depending on regional rather than central action present an especial appeal to the obstetrician.

In my own case, this appeal focussed on the possibilities of lumbar anesthesia in the summer of 1926. Local infiltration had been somewhat used in selected cases for several years, but was most difficult to use in the cases in which we most desired to keep away from inhalation anesthesia, namely, highly toxic patients who by reason of irrational excitation were incapable of the degree of cooperation necessary for success. Caudal anesthesia was later tried, but was less regularly successful, was somewhat more difficult technically, was sometimes too circumscribed in its effect, and was occasionally attended with troublesome psychic disturbance. Parasacral and paralumbar injection appeared to entail a difficult and elaborate technique which did not encourage personal trial.

The American literature at that time recorded general surgical experience with spinal anesthesia, thousands of cases, and many of these had been pregnant women; a few obstetricians had used spinal anesthesia in laparotomies, where they had merely applied surgical experience; only one obstetric clinic, in Los Angeles, was developing this method systematically;[1] the majority of American obstetricians were without any experience whatever; a few had a limited experience but were afraid and distrustful of it.

Surgeons of the greatest experience were insistent on its definite and serious dangers. Babcock[2] stressed the importance of an ever-ready "rescue squad"; moreover, there was and still is, some feeling that pregnant women are especially poor risks for spinal anesthesia. Therefore, our first necessity was to ascertain and demonstrate the *safety* of the method.

The factors upon which we conceived such safety to depend were:

1. Selection of least toxic agent
2. Restriction of dosage
3. Low injection
4. Careful observation of patient and recording of data on each case
5. The utilization of measures to combat fall of blood pressure, urged as the invariable, and one of the great dangers.

At the same time we tried to adopt such refinement of details of technique as would induce maximum efficiency, and minimize trauma and disagreeable sequelae.

Important in this regard are:

6. Choice of size and type of needle
7. Posture for injection
8. Dilution of the anesthetic
9. Amount of barbotage
10. After-treatment.

1. Novocaine was selected as the least toxic agent available. Neocaine has been used alternatively, but except for slightly greater solubility, has not appeared superior in clinical results. A limited use of spinocaine was later made for comparative purposes, but this agent was abandoned. It introduces several foreign substances into the arachnoid sac, which is undesirable except to obtain very definite advantages. These advantages did not appear. Its much vaunted "controllability" of area of effect seemed to us, in carefully controlled comparison with novocaine, mythical. It is less flexible than novocaine in that the posture of the patient is restricted, as it is not with novocaine. Recently, 50 cases were subjected to lumbar anesthesia with nupercaine, but the use of this agent has been abandoned because anesthesia was slower and less certain than with novocaine, nausea, vomiting and headache were of more frequent occurrence, and the headache was of more severe type. This experience has already been reported in detail elsewhere.[3]

2. We began with doses as small as 25 mg., gradually increasing under careful observation of reaction, to doses which we have found adequate for our work. Vaginal and perineal operations are done under a standard dose of 50 mg.; laparotomies, one of 100 mg.; the latter dose is sometimes increased to 150 mg.; there is no fixed indication for this increase, but we feel a little more sure of adequate anesthesia with the larger dose.

3. For vaginal and perineal work the best level for injection is the fourth lumbar interspace; for obstetric laparotomies, the third. It may be noted that we do not employ the "high" classical cesarean section; all our laparotomies are made below the umbilicus, whatever type of uterine incision is made.

4. In the beginning we devised a special form for charting observations, and one attendant's exclusive duty is to watch the patient closely and to chart his observations continuously. In addition to the increased safety of the patient, this relieves the operator of anxiety, and permits the recording of valuable data.

5. Blood pressure variations were at first of much concern to us and in the beginning there was much flurried use of many agents to overcome what seemed like dangerous falls. Especially in originally hypertensive cases are the blood pressure excursions dramatic. We early learned the futility of our panic, and for a long time have employed only two means of offsetting blood-pressure variation and its effect on the economy, namely, the use of 50 mg. ephedrine hypodermatically before the lumbar injection, and the use of the Trendelenburg posture. If the dose of novocaine does not exceed 50 mg. no postural treatment is necessary, but when larger doses are used the Trendelenburg position is utilized, for I believe thoroughly that such posture is essential and is all that is essential to overcome the *effect* of blood pressure fall.

As to the utility of ephedrine, I know of the storm of controversy that is at present raging about it, and have no especial desire to participate in it. It seems to me *a priori* desirable to maintain a physiologic status if possible, especially as every obstetric patient is potentially subject to hemorrhagic shock. Whether we concede the identity of such shock, and the blood-pressure depression of spinal anesthesia or not, it would appear undesirable to have one superadded to the other. In our observation ephedrine does appear to maintain the status *quo ante* in relation to blood-pressure level, in a degree warranting its continued use. In the first consecutive 50 cases (50 mg. novocaine) without ephedrine the mean fall in blood pressure was 26 mm. Hg systolic, 17 mm. Hg diastolic. In a similar consecutive number of cases, using ephedrine, the mean fall in blood pressure was 5.7 mm. Hg systolic, 5.3 mm. Hg diastolic.

We seldom omit ephedrine even in hypertensive cases; it sometimes does cause a slight rise of blood pressure; as we have before pointed out, however, hypertensive cases exhibit the greatest drop in pressure, roughly proportional to the degree of original hypertension; it is just these cases therefore which most need the stabilizing effect of ephedrine.

6. We like a needle of 22 to 20 gauge. We are not convinced that the size has much to do with postoperative incidence of headache, but prefer to use small calibered needles for the sake of a non-traumatizing technique in respect to *all* the tissues traversed. Various types have been tried. The conical pointed needle is beautifully atraumatic, but gives little differential tactile sensation as the various tissue levels are successively penetrated; if bone is impinged upon, the end of the stylet is spread away from the point of the needle itself, resulting in a dangerously tissue-rending prong. The very short beveled needle of Pitkin is too blunt to penetrate the more resistant tissues readily, requiring a pressure which may readily divert it from its true course. In experiments with excised meningeal tissue stretched against moderate liquid pressure we were unable to

demonstrate the alleged "trap-door" opening made by this needle, or any significant difference in leakage through the punctures made by this and other types of needle. We prefer a sharp moderately beveled needle, of which type that of Labat is a good example.

7. Novocaine permits safe administration in either the erect or lateral-prone posture, which is not true of spinocaine. The former is sometimes easier for the anesthetist, but for most obstetric patients the lateral-prone posture is somewhat more comfortable, and entails less handling of the patient, so that we use this posture in nearly all our cases.

8. Small amounts only of spinal fluid are necessary to dissolve and dilute the novocaine. Two and one half cubic centimeters for a 50 mg. dose, to 4 c.c. for a 100 mg. dose, have proved to be satisfactory proportions.

9. The amount of barbotage is also proportional to the dose employed, and the extent of anesthesia desired. In smaller dosages (50 mg.) barbotage results in such dilution of the anesthetic agent that the neurons which it reaches are incompletely anesthetized. When 100 to 150 mg. to a dose is used, barbotage distributes it sufficiently concentrated to a series of neurons numerous enough to obtain anesthesia over an area adequate for our work.

10. The after-treatment is simple. Patients, if they have been in Trendelenburg position on the table, are transported back to bed in this position, and all patients are maintained so for six hours after anesthesia. This permits the blood-pressure level to be gradually stabilized without risk of cerebral anemia, acts as a prophylactic against postpartum hemorrhage, and reduces the shock of any blood loss the delivery may have entailed.

Liquids are permitted during the anesthesia and immediately afterward, and unless there is surgical contraindication, solid food is given at the next regular mealtime.

If headache is complained of, ice applications locally, with moderate doses of salicylic-acid or barbituric-acid compounds suffice for its relief, the patient being kept flat or in slightly inverted posture.

To April 1, 1931 we have given 1832 lumbar anesthesias in 8683 deliveries (21.09 per cent). There has been no maternal or fetal mortality attributable to this method of anesthesia. Failure of anesthesia has been less than 2 per cent. Abnormal reactions during the anesthesia, besides the blood-pressure variations, which have been discussed, have been in all 0.37 per cent of cases, as follows:

Circulatory disturbance indicated by cyanosis and weak rapid pulse, transient	1 case
Severe headache	3 cases
Numbness of upper extremities	1 case
Vomiting	20 cases
Difficulty in breathing, few minutes only	1 case
Marked nervousness and anxiety	6 cases

Postanesthetic sequelae have included the following: Headache, 18 per cent; of these 20 per cent, or 3.6 per cent of the whole, have been severe for a few days; 2 cases only, 0.02 per cent of the whole, lasted four and twelve weeks respectively; one case of mild paresthesia of the thigh lasted eight weeks, and one of the calf and heel, two weeks.

The action of spinal anesthesia on the course of labor is to retard it. Thus, if given electively near the end of the second stage of cases presumably capable of spontaneous delivery, two-thirds of them will be arrested, and will require artificial aid. They will deliver normally, however, if time be given to allow the wearing off of the anesthesia.

This effect does not depend on abolition of the uterine contractions; the presenting part may be seen advancing and receding during this period of arrest, in response to rhythmic uterine contractions, of approximately the same periodicity and duration as before the administration of the anesthetic. Uterine relaxation and bleeding during the third stage and post partum is not increased. Under direct vision in cesarean section the contractibility of the uterus is prompt and vigorous. The action of oxytoxics on the uterus is not impaired.

A limited series of pressure observations, with a specially constructed manometer attached to a hydrostatic bag placed within the uterus, indicated no essential change in the power of the contractions.

The retarding action on labor would appear to depend, therefore, on the loss of the auxiliary powers, partly due, no doubt, to slight depression of the voluntary motor power of the muscles, but mostly dependent on the abolition of the sensory phase of the sensory-motor reflex which normally brings these forces into play. This confirms De Lee's statement: "After dilatation of the cervix the abdominal muscles alone are able to expel the child, and usually do it, since the uterus by this time, . . . has very little expulsive power."[4]

Spinal anesthesia produces good relaxation of the soft parts but not as much as deep surgical narcosis with chloroform. It is sufficient, for instance, to facilitate podalic version employed under proper conditions. Statements that it causes magical disappearance of resistance in undilated cervices, and entire avoidance of potentiality of perineal laceration have not been borne out in our observation, and we believe they are misleading and dangerous.

The effect of spinal anesthesia on the fetus is nil. In no single case has apnea been observed not dependent on causes other than the anesthesia. Moreover, repeated observation has shown that morphine administered to the mother in average therapeutic dose during the first or second stage, regardless of the interval until the birth of the child, does not cause fetal asphyxia; we therefore regard the apprebrium attributed to morphine in causing fetal apnea, to be more justly ascribable to the combined effort of that drug and general anesthetics. Williamson[5] has recently made the same observation relative to infiltration anesthesia for the termination of the second stage of labor.

Lumbar anesthesia is not a method for first-stage, or for prolonged second-stage, analgesia, by reason of its short duration. It is therefore not an alternative for opiates, synergistic analgesia, pernocton, avertin, or inhalation agents used for this purpose.

It does, however, offer the obstetrician a means of absolute anesthesia, non-toxic, and not otherwise dangerous to mother or baby. It does not increase the danger of hemorrhage. The absolute quiescence of the patient assists in the maintenance of aseptic technique, and the facility of abdominal operative procedures, and minimizes the postoperative morbidity of the latter. The absence of toxicity is especially significant in a large group of patients handicapped by pulmonary, thyroid, heart, hepatic and renal disease.

These advantages it shares with all types of local or conductive anesthesia, but excels all other types in simplicity and effectiveness.

It is applicable to the termination of the second stage of labor in:

1. Normal cases in which analgesia requires to be supplemented by true anesthesia, provided the obstetrician is prepared to accept a largely increased necessity for elective artificial delivery.

2. All cases initially requiring operative delivery, by either the vaginal or abdominal routes.

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TUBERCULOSIS OF THE LARGE INTESTINE*

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THE subject of this paper, Tuberculosis of the Intestine, as given, is too comprehensive, as my real object is to present 4 cases of hyperplastic tuberculosis of the large bowel, and to deal more fully with that form, merely mentioning the other two varieties.

Intestinal tuberculosis manifests itself in three pathological forms: ulcerative, fibrous, and hyperplastic. The first, the most frequent, is a complication of pulmonary tuberculosis, occurring, according to Larimore and Fisher, in 60 to 90 per cent of all cases coming to autopsy. Kaufman claims that 90 per cent of adults having pulmonary tuberculosis have intestinal involvement.

The second is evidently a sequel to the ulcerative class, a result of the healing of the ulcers by the usual process of fibrous tissue formation, occasionally forming a stricture. The occurrence of such strictures, to my mind, is exceedingly rare, as the general constitutional involvement at this stage is too great.

The third variety, hyperplastic tuberculosis of the intestine, is a term to which Herrick objects, preferring the classification "tuberculoma," claiming that it is not a process of hyperplasia, but a chronic inflammation and infiltration of the bowel walls, and an overproduction of fibrous tissue.

This group has been regarded as quite rare, but I am inclined to believe that its rarity is more imagined than real. It remained unrecognized as clinical and pathological entity until 1890 when abdominal surgery directed attention to tumor-like formations occurring in the cecum, associated with tuberculosis. Durante, Billroth, and Hartmann and Pilliet, later many other investigators, called attention to these growths which simulated carcinoma, clinically and macroscopically, but microscopically proved to be tuberculous. We are indebted to Hartmann and Pilliet for a detailed description in 1891 at which time the true character of these tumors was established. Further report was made by Hartmann in 1906, of 219 patients, operated upon with 45 deaths.

The intestinal distribution of the growth, in a collected group of 100 cases by Mummery is as follows:

Sigmoid flexure	6
Cecum	48
Cecum and ascending colon	39
Whole colon	4
Cecum, ascending and transverse colon	3

The 4 cases I am reporting are as follows:

Cecum	1
Cecum and ileum	1
Sigmoid	1
Rectum	1

The rarity of tuberculosis in the small intestine is illustrated by a recent article by Cunningham and Sneierson, reporting the ninth case.

ETIOLOGY

The etiology offers difficulty of study; the fact is few surgeons have had opportunity to study more than 2 or 3 cases; furthermore, the cases have not been carefully studied. The only decision concurred in by all is that they are amenable to surgical interference.

Apparently no case has been studied sufficiently to determine whether the infecting organism is of the human or bovine type. I regret to plead guilty of the same negligence.

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It is evident that the occurrence of this form of tuberculosis is largely confined to the large gut. Its predilection for the

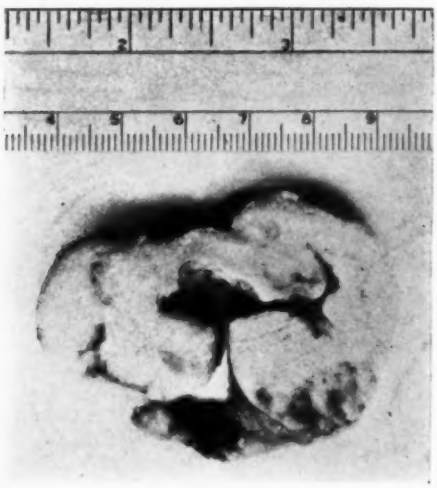

Fig. 1. Cross section through the sigmoid just proximal to the point of obstruction.

cecum and contiguous tissue cannot be more than surmised; that this site is selected because of the physiological function of the cecum, being an absorbing reservoir, makes for a longer delay of the intestinal content, in this portion of the intestine, most richly supplied with blood vessels, lymphoid glands, and Peyer's patches.

The rarity of association in pulmonary tuberculosis is illustrated by a study of tuberculomas, as well as a study of patients suffering from advanced pulmonary tuberculosis. In the Eudowood Sanitarium, with which I have been associated since its organization, as surgeon, we have treated 7698 tuberculosis cases, and never have we found a single case clinically pointing to intestinal hyperplastic tuberculosis, while the ulcerative form is present in the vast majority.

This is further borne out in a recent report by Rubin in 500 consecutive autopsies; 324 showed macroscopic tuberculous ulceration, or about 65 per cent. In the group below age of thirty-one, 78 per cent; above fifty years, 39 per cent.

The intestinal distribution was as follows: duodenum 1.6 per cent, jejunum 28 per cent, ileum 74 per cent, appendix 22 per cent, cecum 60 per cent, colon 42 per cent, rectum 11 per cent. There being no mention of the occurrence of the hyperplastic type, it is a fair assumption of its non-occurrence.

The question of the mode of entrance of the organism has suggested three theories: first by the direct entrance from the intestinal content; second by blood stream; and the theory of Shennan, of retrograde infection from the mesenteric glands.

The blood stream infection is suggested by Calmette, who believes that the bacilli pass through the mucous membrane, lodge in the regional lymphatics, and set up a pathological reaction, producing scar tissue and not ulceration.

Reasoning from clinical data, the greater frequency of the involvement of the cecum in pulmonary involvement, and the strong probability of intestinal involvement being due to swallowed tuberculous sputa, it would seem that the most plausible explanation of large gut involvement in the hyperplastic form is due to a weak or attenuated organism being ingested and lodged in a favored site or media, or due to a greater resistance on the part of the individual. In other words, a primary tuberculosis situated in the large intestine, in which the usual warfare goes on between the attack by the tuberculosis bacillus, and the individual, with the result that an inflammatory reaction is set up, with the production of fibrous tissue, which is the normal manner of healing in tuberculous healing.

The existence of the disease can only be determined after a most careful consideration of all the symptoms presented, and its existence must be inferred, rather than positively affirmed. Many of the symptoms are common to a number of affections, such as abdominal tumors, intestinal peritonitis, affections of the right kidney, and of the tubes and ovary of the female. The symptoms most commonly observed are weakness and loss of flesh, lasting over a long period, the evolution of the condition, although continuous, being slow and possi-

bly dependent upon a bacillus of attenuated virulence. Constrictive crises are usually noted, due to the arrest of the intestinal contents at the strictured points, with localized distention, possibly with visible peristalsis of the intestinal coils, the result of localized tympany.

These attacks are followed by cessation of the pain after characteristic borborygmi are heard, due to the passage through the obstruction of gas. These attacks of colic may or may not be attended by vomiting.

Moderate constipation in the earlier stages, with occasional attacks of diarrhea are common; but the latter symptoms may not be more pronounced and persistent than is often accidentally present in individuals without any intra-abdominal lesion.

Except in the latest stages, the vomiting suggests neither distinct intestinal obstruction nor appendicitis. There is no characteristic painful spot, there is absence of all general distention and of the fever so common in appendicitis. The tumors are more or less mobile, steadily increase in size, are often multiple, and are apt to assume a cylindrical form; they are usually tender when gently palpated.

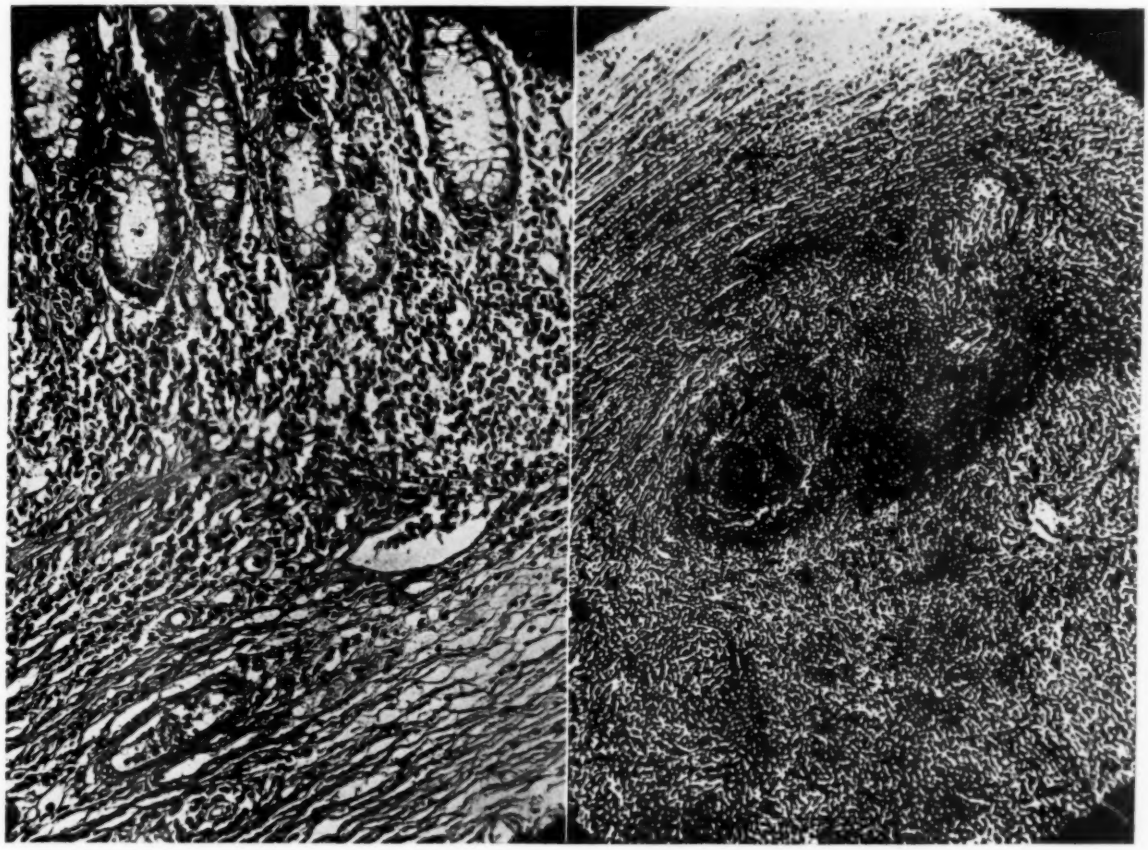

Fig. 2. Fig. 3.

Figs. 2 and 3. Fair preservation of glands of mucosa with intense round cell infiltration and fibrosis throughout submucous layer. Tubercle lying in infiltrated scar tissue just below serosa.

The differential diagnosis must be made chiefly from malignant tumor of some abdominal organ. The coexistence of pulmonary lesions seems very exceptional. These tuberculous conditions are more prone to occur at an earlier age than carcinomatous disease; nevertheless, so many young individuals do suffer from malignant tumors that this point is only of relative value. A tuberculin test may settle the question.

CASE REPORTS

Case 1. (B. S. H. No. 4998). White male, aged nineteen, June 11, 1930. (Dr. Stiles.)

Past History: Uneventful except that he had had slight attacks of the present illness over period of two or three years. These were characterized by more or less pain in the epigastric region and nausea. Apparently not related to taking of food, and always cleared up within a few hours after onset. Bowels always regular.

Complaint: Pain in right lower quadrant of abdomen. Had been apparently well until two days before coming to hospital, at which time he had slight pain in the epigastric region, felt sleepy and thought he had fever. Was nauseated but did not vomit. Better next day but on following day pain returned and seemed to radiate from epigastrium down the right side of the abdomen, finally becoming localized in the right lower quadrant.

General Examination: Fairly good physical condition, quite toxic. Temperature 101°F., pulse 114.

Abdominal Examination: Revealed definite tenderness and rigidity in the right lower quadrant, with an indefinite impression as to the presence of a mass in the region.

Laboratory Report: Leucocyte count was 16,400 with 80 per cent polymorphonuclears. Hemoglobin was 96 per cent.

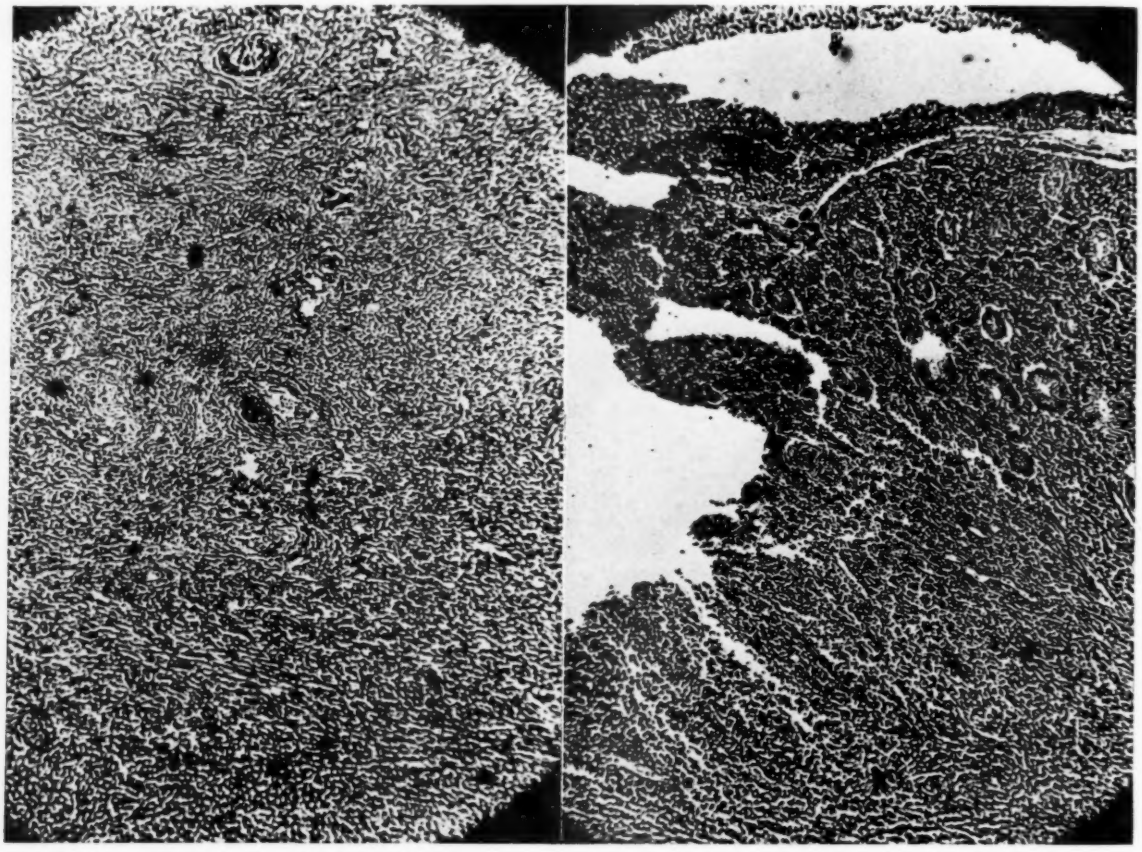

Fig. 4. Fig. 5.

Figs. 4 and 5. Replacement of old normal tissue with fibrosis, markedly infiltrated with round cells and showing giant cell formation. Replacement of mucosa with inflammatory tissue, markedly infiltrated with round cells. Few badly damaged mucosal glands survive.

Preoperative Diagnosis: Acute appendicitis with abscess formation.

Gross Specimen Examination: Consisted of a small portion of ileum, the cecum and part of the ascending colon. Appendix, which could not be demonstrated at first was found to make up the major portion of the tumor. The mass was about 10 cm. by 5 cm., fairly regular in outline and very firm in consistency. Upon opening the bowel, the mucosa appeared intact and there was no marked stenosis. On section, the lumen of the appendix was found to extend almost throughout the mass. The cut surface of the tissue was dense and fibrous and was of a dull white color.

Microscopically: There was a good deal of fibrous tissue and marked inflammatory re-

action. There was no evidence of malignancy. Tubercles and giant cells were found after much study.

Result: Patient discharged after twenty-seven days, and when last seen a short time ago was in good condition.

Case II. M. C., aged forty, married, white male. September, 1929.

Chief Complaint: Pain in right inguinal region, urethral discharge.

Past History: Usual childhood diseases. Had right hernioplasty in 1915 and left hernioplasty in 1926. Also a gonococcic infection 1926.

Present Illness: Patient states that he received a gonococcic infection three years ago. This was followed by a discharge and burning on urination. Also had a sore on glans penis which was accompanied by enlarged inguinal glands, especially the right side. Since then has been having pain on right side and a morning drip.

General Physical Examination: Essentially negative except for absence of left testicle and a large rough hard mass around the rectal orifice resembling condylomata. Genitourinary studies including cystoscopy and *x*-rays of the kidney regions, both before and after injection of sodium iodide, resulting in a diagnosis of right renal calculus with pyonephrosis.

Impression: Gonococcic urethritis, chronic. Absence of left testicle. Lues. Chronic prostatitis. Prolapse of rectum. Probable renal calculus on right. Stricture of sigmoid colon, probably tuberculous.

Blood Pictures: Hemoglobin 44 per cent, red cells 2,680,000, leucocytes 16,700, polymorphonuclears 90 per cent.

Postoperative Diagnosis: Renal calculus, right, tuberculous. Tuberculosis of sigmoid colon, also stricture.

On September 28, 1929, right nephrectomy was done. This kidney showed a diffuse nephrosis, fairly large renal calculus and a number of small tubercles under the kidney capsule of the upper pole.

I saw the patient and after sigmoidoscopy, found a stricture of the sigmoid colon which I attributed to tuberculosis. On October 21, abdomen was opened by a left rectus incision, sigmoid brought to the abdominal wall and sutured to the peritoneum and skin. On opening the abdomen, I found numerous tubercles over the peritoneum.

On October 23, colostomy was completed with the electrocautery. The specimen removed at that time was a large thickened sausage-shaped mass which was submitted to Dr. Gichner for study, the report of which is given below.

Laboratory Report: Smear negative for gonococcus. Sputum negative for tuberculosis, many pus cells present.

Laboratory Report: Gross: Bowel is markedly thickened throughout. Kidney shows diffuse nephrosis.

Macroscopic: The wall of the intestines, all layers, is markedly thickened and there is great round cell infiltration throughout tissue. Here and there there is a mass of lymphoid cells, fibroblasts and typical giant cells. In no area does tissue show evidence of caseation.

Microscopic: Several hemorrhagic areas surrounded by round cell infiltration would strongly suggest tuberculosis; however, no typical tuberculous giant cells were seen. Further investigation of kidney reveals areas in which definite confluent tubercles are seen.

The patient ran a stormy postoperative course and died on October 31, 1929.

Case III. L. M., Case No. 14,662, white female, married, housewife. (Under service of Dr. Herbert Blake.)

General Examination: Well-developed, well nourished woman. Negative except that symptoms pointed to abdomen.

Chief Complaint: Dull aching pain in right lower quadrant with history of beginning trouble January 16, 1930. Temperature slightly elevated, according to her statement, but no elevation of temperature on admittance. No nausea, no vomiting, but has had recurrent attacks of cramps, confined particularly to this region.

Fluoroscopic Examination showed visceroptosis. Some diarrhea at times.

Abdominal Examination: Small palpable mass over McBurney's point with tenderness and some rigidity. The clinical diagnosis was "appendicitis."

Laboratory Report: Blood pictures showed slight degree of anemia, red cells, 3,710,000, leucocytes 11,800, polymorphonuclears 78 per cent.

Urine, negative.

Stool, dark brown color, semi-liquid, much mucus, positive for blood (microscopic), negative for parasites and ova.

Operative Procedure: Was prepared for appendectomy but on finding this mass, 6 in. of small intestine and 3 in. of large intestine, including the cecal valve, were removed and then anastomosis done. Patient made a complete recovery.

Postoperative Diagnosis: Inflammatory mass of cecal valve and surrounding intestines, partial obstruction. Found no evidences of involvement of mesentery glands nor any indication of any pulmonary involvement.

Laboratory Report: Gross: Specimen consists of cecum, ileum, and appendix. The wall is everywhere tremendously thickened and shows an evenness of thickening which does not grossly appear malignant. In the cecum there appears to be one area of definite overgrowth involving the valve. This tissue is of greater hardness than the remaining portions.

Microscopic: The appendix shows considerable active inflammatory change involving particularly the lymphoid tissue, with here and there areas of degeneration, and other areas in which lymphocytes surround a center wherein the cells show degenerative changes. The walls of the gut are thickened, edematous, with areas of lymphocytic infiltration, at the borders of which occasional multinuclear giant cells can be made out. The pattern of the mucosa is fairly well preserved although there is some superficial necrosis. The accompanying lymph gland shows marked overgrowth of fibrous stroma and many degenerated areas where the lymphatic cells have been replaced with hyaline tissue.

Final Examination: Tuberculosis of cecum and ileum.

Last report from patient was that she had gained 8 lb. in weight, and felt perfectly well. Regular bowel movements. Appetite and general condition good.

Note: This case demonstrates the not infrequent confusion of appendicitis with cecal involvement in these conditions. Of course, the operation immediately disclosed a large mass which was considered inflammatory but was removed because of its obstructive symptoms, and a final diagnosis could not be made until microscopic sections were taken.

The lack of involvement of mesentery glands in such a large mass lessened the probability of a malignancy, as in these cases involvement does not ordinarily spread to the glands unless there are other tuberculous lesions in the patient.

Case iv. A. S. colored, aged thirty-two, married, laundress. October 1919.

Chief Complaint: Pain in back, lower part of abdomen. Pain continues day and night. Constant discharge from bowels.

Family History negative. Has had one child. No history of tuberculosis. Denies venereal disease. Other than childhood diseases, had been healthy.

Present Complaint: Patient noticed lump in rectum which often protruded and caused her to go to the toilet frequently. With treatment by home remedy, it returned to place and pain ceased. Three months later pain returned and 3 or 4 more lumps appeared, compelling her to have defecation every five minutes, with great straining and bearing-down pains. These symptoms continued up until the present time; occasionally red blood and small clots had passed with her stools. Pain had grown worse progressively and localized itself particularly in the rectum and lower part of the back. At times passed quantities of mucus and pus, always had straining. At present moment has incontinency of feces. Complains great deal of gas and pain.

Habits: Negative.

General Physical Examination: Head, neck, heart, abdomen, and lungs normal. No genitourinary symptoms with the exception of frequency of urination. Menses have been regular until past month when one period was missed. During the past year has lost a great deal of weight. Always has sensation of full feeling in rectum.

Examination: Several condylomata with several fistulous tracts leading into perianal tissues.

Internally, mass about 5 cm. above sphincter, involving entire rectum and protruding and lifting itself into the vagina, but no involvement of vaginal mucosa. Vagina clear except profuse discharge. Mass is irregular in shape, lumpy, several ulcerations. Bowels obstructed to lumen about size of lead pencil.

Laboratory Report: Wassermann reaction.

Vaginal smears: many pus cells, negative for gonorrhea.

Urine: negative except few pus cells.

Diagnosis: Stricture of rectum, probably syphilitic in origin. Fistula in ano. Small piece of tissue removed for examination, stricture dilated. Following diagnosis, patient declined subsequent operation.

Following her dilatation, three weeks later patient had improved generally. Bowel movements, well-formed stool and no diarrhea.

Specimens were submitted to the hospital pathologist who gave as his impression from microscopic section that it was a syphilitic stricture. Two studies were made by Dr. Bloodgood and his results were as follow:

Microscopic: The section showed granulation tissue filled with numerous tubercles and giant cells. The histological picture of tuberculosis. In the center of the section, surrounded by the tuberculous granulation tissue, there are a few dilated mucous glands of the rectum, mucous membrane, but here there is no picture of adenocarcinoma. The glands are dilated, lined by a single layer of columnar epithelium and filled with mucus.

This case illustrates involvement of the rectum with hyperplastic tuberculosis. Careful examination was made of the lungs and no evidence of involvement could be seen.

An operative procedure to have relieved this condition would necessarily have destroyed the sphincter mucosa and given loss of bowel control. The suggestion was made to the patient to have a colostomy done primarily, and then to remove the entire rectum or as much as would have been necessary. This she declined.

The high points in the history of these cases:

Diagnosed as acute appendicitis with abscess. Chest negative for tuberculosis. (Case of Dr. Stiles.)

Diagnosed as rectal stricture, syphilitic. No clinical signs of tuberculosis. (A. S.)

Diagnosed as appendicitis, chronic. Intestinal stricture, with appearance of tuberculoma. Tubercles, peritoneum. Tuberculous kidney. (Dr. Blake, M. C.)

The unusual: One located in rectum. One, tuberculosis in other organs.

Results: Three good operative results. One death of general asthenia.

CONCLUSIONS

This condition is not so rare as is believed. An operation is essential, and results are good. Preoperative diagnosis is impossible. The condition demands immediate relief. Careful microscopic study makes for a favorable or bad prognosis. More study should be done to determine the kind of bacillus, bovine or human.

I am indebted to Dr. Cleo D. Stiles, Jr., and Dr. J. K. B. E. Seegar for the privilege of reporting their case, a patient at St. Agnes' Hospital. I am also indebted to Dr. Herbert Blake for the privilege of reporting his case, a patient at the West Baltimore General Hospital. The other 2 cases occurred at the West Baltimore General Hospital and at the University Hospital, Department of Proctology, under my service. I should like also to thank Dr. Manuel Gichner, Pathologist at the West Baltimore General Hospital for the interpretation of the photomicrographs, and to Dr. Carl Clarke, Head of the Art Department at the University of Maryland, for their preparation.

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RIGHT HEMICOLECTOMY WITH ILEOCOLIC TUBE DRAINAGE*

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WITHOUT specifying all the pathological conditions or changes of the right colon that require right hemicolectomy, I have selected two illustrative lesions for which this operation had been performed.

The intestinal ends were joined by an end-to-end union and an ileocolostomy rubber drainage tube was inserted and so arranged that it demonstrated some useful features of practical value.

If I interest readers in a single problem in the Art of Surgery: namely, right hemicolectomy, it may serve to focus attention on other latent opportunities for practical trial and research in this field.

Recently the exaltation and glorification of the Science of Surgery has tended to obscure the importance of the Art of Surgery.

Discussions as to the relative importance of the divisions of Surgery, Art versus Science, are never satisfactorily ended. Strong and earnest advocates of each class are quick to emphasize and express their preference, depending entirely on personal inclinations and beliefs.

Believing as I do that the ideal surgeon requires excellent qualities of head, hand, and heart, and must be a composite thereof, I hold no brief for the pure technician, the exponent of manual dexterity in our ranks, who often is so one-sided that he sets aside real thinking, sound reasoning and good judgment as items of secondary importance.

It must be appreciated that science may envisage new fields and explore the unknown, and that a broad and sympathetic encouragement must be given to such work, that the results thereof be carefully estimated, appreciated and accepted only when worthy. In surgery particularly, it is important not to follow too quickly nebulous fancies, speculations, and unproved theories hastily accepted when garbed as science.

It can be definitely stated that pure science cannot advance alone from its test tube, animal experimentation, laboratories or the morgue. Such work must be transported, translated and activated by competent and skilled craftsmen of the Art of Surgery into measures useful for the living.

It continues true, that the demand of humans is that, when required, operations upon us be done by trained mechanics, not theorists; skilled performers, not laboratorians; but by competent surgeons trained in the Art of Surgery.

E. Starr Judd[1] in a presidential address before the Western Surgical Association concluded as follows: "Perfection of the Art of Surgery can be obtained only by constant practice, and only those who are willing to spend much time and effort in the development of this sort of craftsmanship, along with their studies of the Science of Medicine, will have an opportunity to become the real Artists of Surgery."

Surgically, the entire colon may be divided into a right and left part. Important differences in these two halves have made this somewhat arbitrary cleavage of practical and basic use for any operative consideration directed thereto.

Embryologically, the right colon was derived from the midgut, the left colon from the hindgut. The superior mesenteric artery through its branches and arches of the ileocolic, colica dextra and colica media give an adequate and a rich blood supply to this part of the colon, whereas

* Read by invitation before the Brooklyn Surgical Society, January 2, 1931.

the left colon supplied in main by the inferior mesenteric artery and a left branch of the colica media does not receive so generous a vascular series of arches of blood (Fig. 1). The entire colon maintains its blood vessels on the inner leaf of the mesentery. Its lymphatic system is carried with it. The outer leaf may be considered an avascular layer.

Usually, the contents in the right colon are fluid and therein the number of bacteria is fewer and less actively infectious than in the left half. Obstructions on the right side are often less complete. The general effects of such a blockage are not so disturbing or toxic. Local intestinal wall damage is better tolerated.

All the principles that are essential for the removal of the right colon have been well accepted and standardized for its accomplishment. The type of anastomosis best performed for the bowel ends continues to be vigorously debated.

An essential requirement is a free and avascular mobilization of the ascending colon by splitting the outer leaf of peritoneum near its attachment to the posterior parietal wall, liberating the proximal half of the transverse colon by lifting the omentum from its attachment to that area and severing the ileum about 6 in. from the ileocecal junction.

It has been my plan, first to start on the ileum by sectioning that bowel with the actual cautery (Fig. 2) then doubly clamping the ileal mesentery toward the ileocecal area. The second step has been to split the outer mesenteric leaf of the cecum, ascending colon and hepatic flexure (Figs. 3 and 4) permitting this portion of the colon to rise high up, after which the omentum has been detached from the transverse colon (Fig. 5). All this completed will permit these parts to hang loosely and easily on its inner or vascular blade so that the blood vessels can be clearly seen, doubly clamped, divided and tied. Attention to the right ureter and the right spermatic vessels in this area must be observed.

Often the greatest difficulty is encountered at the corner of the hepatic flexure. Here, the colon must be carefully stripped

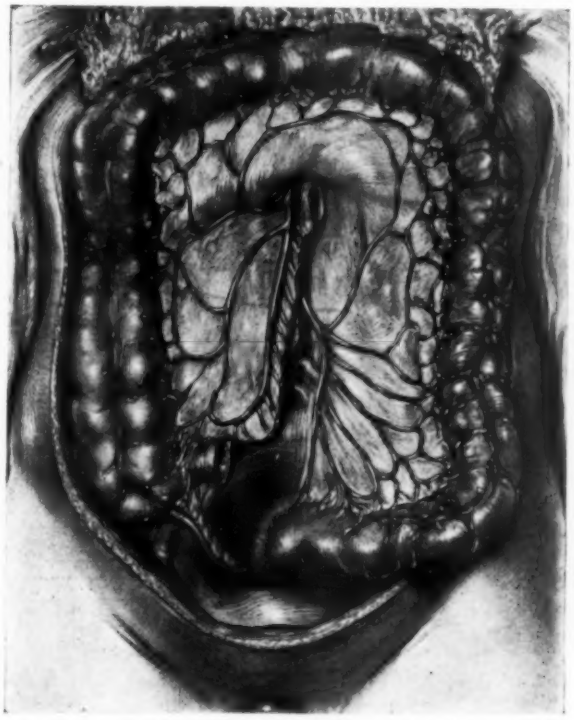

Fig. 1. Anatomical study of colon to visualize vascular arches.

downward and inward and the supporting ligament and vessels carefully isolated and tied. Guarding the duodenum at this point is necessary as injury to this structure is not infrequent. Now, the transverse colon is divided between clamps (Fig. 6) and the entire attacked intestine with a large part of its mesenteric attachment is removed.

Finally, I have united the ileum to the transverse colon with an axial, straight-line, or end-to-end union (Fig. 7).

I have introduced a rubber tube (No. 20 F. catheter) into the ileum, through the stoma and into the transverse colon, to provide intestinal drainage and maintain the patency of the stoma (Fig. 8). Separate openings as eyes in the tube are provided for both the transverse colon and the ileum.

About 4 in. from the anastomosis, this tubing, after its introduction into the

ileum, is fixed at its point of aperture with two rows of purse-string sutures and the distal or free end of the catheter is

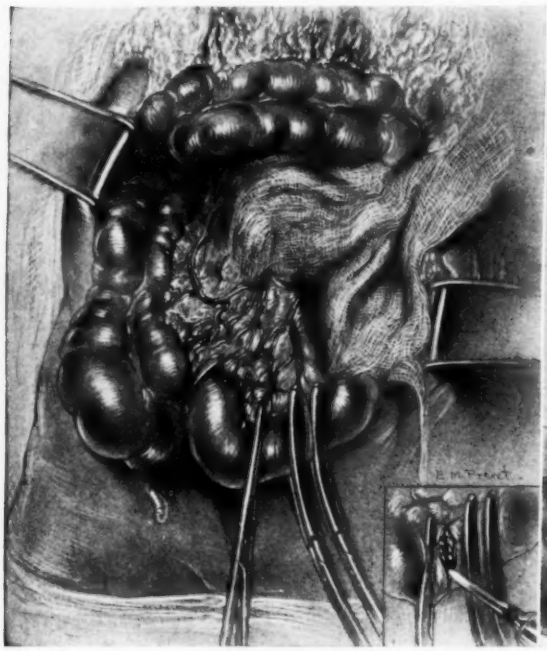

FIG. 2. Ileum sectioned with cautery after three clamps have been arranged thereon. One crushing clamp is placed distally and two flexible rubber sheathed clamps placed proximally to line of section. When caudally placed ileal clamp is removed, there will be sufficient bowel to perform ileocolic anastomosis.

FIG. 3. Splitting outer leaf (avascular) of peritoneum, permits rapid and bloodless scissor and finger mobilization of cecum and ascending colon.

carried under and through a small opening made into the great omentum which had been detached from the sectioned transverse colon (Fig. 9). This allows that portion of the omentum to lie flat over the anastomosis. No suturing is required.

Through a separate stab-wound into the abdominal wall or from the original wound itself, the catheter may be allowed to have its exit. This depends upon how the catheter will best arrange itself without the least distortion.

The results of every recent bowel anastomosis axial, lateral, or end-to-side, involve similar difficulties that vary only in degree. These may be divided in a primary or immediate group, and a secondary or delayed group. Under the *primary*, we list:

1. Local soiling
2. Inadequate blood supply
3. Edge tension
4. Hemorrhage
5. Marginal constriction
6. Stoma, immediate size and patency
7. Coverage
8. Infectivity
9. Type of intestinal content.

In this group are errors mainly of technical character.

Secondary or delayed group:

1. Marginal gangrene
2. Closure of stoma due to excessive contractions
3. Excessive exudate narrowing the stoma
4. Marginal abscess
5. Local paresis
6. Local retention of fecal contents
7. Ballooning of blind stumps
8. Blow out of closed ends
9. Local abscess
10. Kinking of segments
11. Fecal fistula.

In this second group, many of the mentioned factors interfering after a satisfactory anastomosis has been completed,

occur as a result of the failure of fecal contents, gas, fluids or solids to be properly propelled forward, causing increased ten-

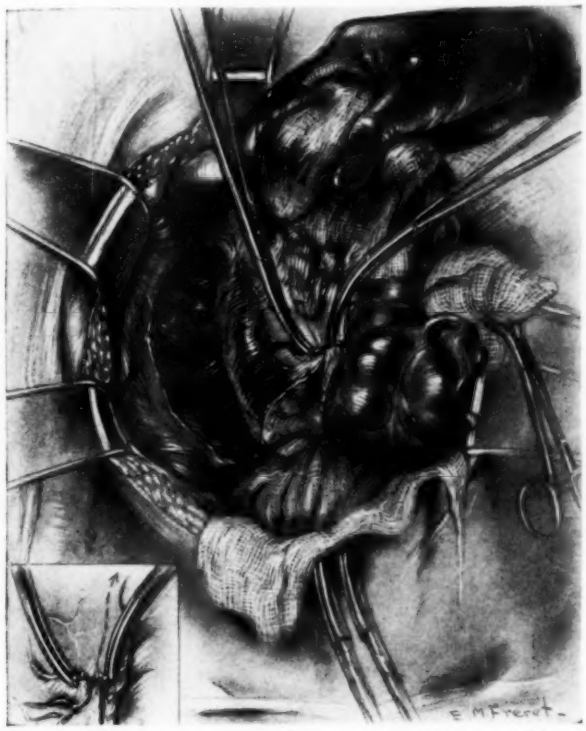

Fig. 4. Cecum and ascending colon rolled over. Blood vessels can be viewed, clamped, cut and tied.

sion on the suture lines, thus permitting the infective material to press on to freshly coaptated bowel edges and thereby damaging the stoma and its component parts.

Although a classification into such groups may not be sharply defined and exact, it will serve to a better understanding of some of the hazards inherent in all anastomoses and of measures to decrease them.

The difficulties which not infrequently confront the surgeon in carrying out operations on the large and small intestine are to a considerable degree overcome by his familiarity with the established principles of intestinal surgery; his ability to employ technical methods of proved value and to utilize the various mechanical devices which, in the development of surgery of the gastrointestinal tract, have been employed to meet special conditions arising during operation.

Of the mechanical devices the rubber tube, I believe, deserves more general and favorable recognition than is at present accorded it. Its usefulness in certain intestinal operations has been very evident, and the results of such operations so gratifying, that it seems appropriate to

Fig. 5. Great omentum is detached from transverse colon on right side to liberate it and help mobilize hepatic flexure.

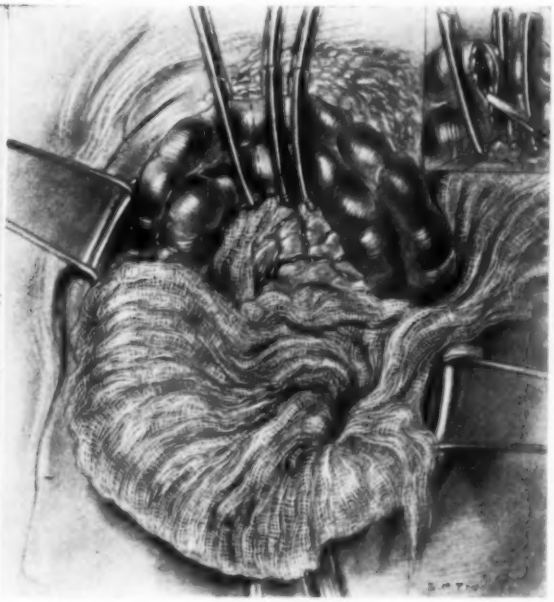

Fig. 6. Transverse colon sectioned with cautery after three clamps have been placed. One crushing clamp proximally and two flexible rubber sheathed clamps distally to line of section. When rubber covered clamp nearest cut end is removed, there will be ample bowel to perform ileocolic union.

record these two instances of right hemicolectomy wherein it has been employed.

Exactly how, when, and where rubber tubing first made its introduction to intestinal surgery, and the subsequent steps thereafter will not serve any particular purpose in this paper.

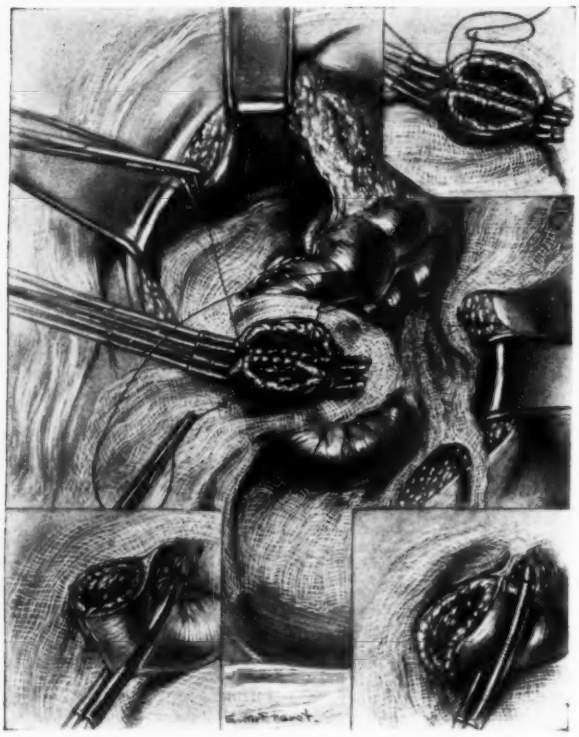

FIG. 7. End-to-end anastomosis of ileum to transverse colon. Insets, to show how ileal end may be widened by split on antimesenteric border to approximate same circumference as cut end of transverse colon.

In 1910, Balfour[2] reported its value in resections of the left colon, especially at the rectosigmoid, a procedure that became generally known as the Balfour tube resection. He, however, gave credit to his predecessors, Rutherford Morison, Lockhart Mummery, and other English surgeons.

It has been the frequent and better experience of many surgeons that tube drainage is a highly desirable and essential part of the technique in many resections with union on the left colon. To utilize a piece of rubber tubing through the stoma and to carry it through the anus to the external surface provides a ready exit for fecal contents. It also controls the patency of the stoma and furnishes a scaffolding for plastic exudate to form upon. As a splint, it maintains the position of the segments of intestine at rest and free from angulation.

Little mention has been made of the use of rubber tubing for similar purposes on the right colon. Occasionally as a direct enterostomy tube it has been set into the ileum about 7 in. above the ileocolic union. More often, it has been employed as tube drainage for the open ends of the colon or ileum.

Horsley,[3] after speculatively considering the advisability of a rubber tube drainage through the stoma of a direct ileocolostomy union, employed this method in a case. He, however, introduced the tube through the colon, stoma and then into the ileum.

Unlike the step procedures required for the left colon, as a general measure resections of the right colon are accomplished in one stage. The restoration of the continuity of the intestinal tract may be performed in many ways. Probably the most popular union of ileotransversostomy continues to be the lateral one. Next in the order of frequency is the end-to-side operation and finally the axial or end-to-end anastomosis.

There seems to be a tendency lately, however, to reverse this order. John F. Erdmann[4] has long been a user of the line type of anastomosis.

The objectors to the lateral anastomosis have maintained that a finished procedure leaving two blind stumps and three suture lines carries a serious defect. There are too frequently recorded instances of early and late blow outs of the blind ends. Longitudinal incision of the transverse colon and ileum interferes with a large area of neuromuscular activity thereby subjecting the local area to excessive paresis, local contractions and greater interference to the onward propulsion of fecal contents.

End-to-side anastomosis carries one-half of these objections whereas axial or end-to-end anastomosis reduces to a minimum all of the faults of theoretical or practical consideration.

Nevertheless, certain difficulties will occasionally arise even under the most favorable conditions and effort, which

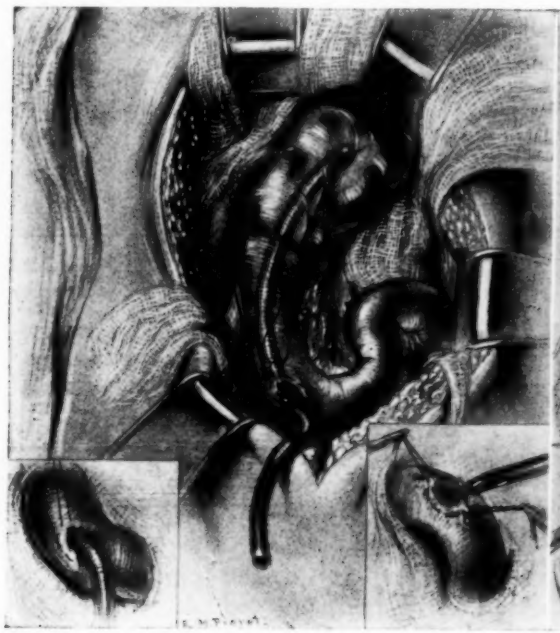

Fig. 8. Introduction of rubber tube with two eyes, into ileum, through ileocolic stoma and into transverse colon.

may be partly overcome by the use of an ileocolic tube, such as I have described, to conduct a large part of the intestinal contents to an external surface. This tube, as described and pictured when withdrawn from the intestine, leaves an opening in the ileum which usually closes spontaneously and promptly.

Case 1. B. R., a female, aged forty-three years, was admitted to the Israel-Zion Hospital, July 1, 1930, with a temperature of 100°F.

Marital History. The patient had been married seven years and had four children. The last pregnancy occurred two years ago.

Past History. She recalled that five weeks after her last delivery, she developed mild lower abdominal pains. The patient described the pain as "pin and needle-like," intermittent, lasting an hour at times. She was very indefinite as to its exact location. Occasionally the pain radiated to both flanks. It was never limited to the right lower quadrant. No history of persistent nausea, belching, vomiting, cramps or diarrhea could be obtained.

Present Illness. Eight hours before hospitalization, patient complained of severe abdominal cramps centered to the right lower quadrant. She had no nausea or vomiting, but felt distinctly chilly.

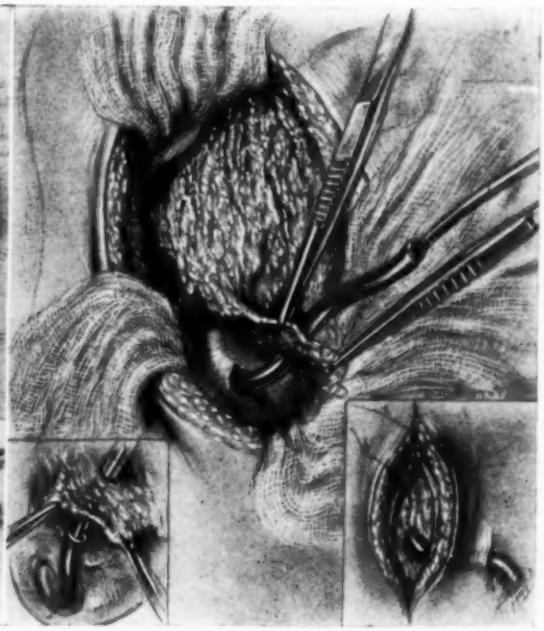

Fig. 9. Tube carried through omentum which will protect ileal aperture and help close it. Inset, rubber tube withdrawn through stab incision in abdominal wall.

Physical Examination. Patient is an obese female moderately ill. The heart was not enlarged; the lungs were noted to have râles due to chronic asthma. Abdomen was only slightly distended. In the right lower quadrant was a wide area of local tenderness with definite resistance of the underlying muscles. Rebound tenderness was marked. It was estimated that the most tender spot was over McBurney's point.

Vaginal Examination. No pelvic pathology. Urinalysis (faint trace of albumin), and blood examinations (total white blood cell count 12,500; 76 per cent polymorphonuclears).

The Preoperative Diagnosis. Acute appendicitis.

Operation and Operative Findings. Through a right gridiron or McBurney incision, the cecum was found to be involved by a mass formation the size of a fist. The tumefaction occupied most of the outer and lower half of the cecum. The pathological diagnosis was indeterminate; carcinoma of the cecum received the most consideration.

The specimen when incised postoperatively showed a calloused ulcer of the outer side of the

cecal wall. It had raised smooth edges. A rounded opening about ½ in. in diameter led into a large pocket within the cecal wall. Purulent fluid was in the retention cavity. The cecal wall was tremendously thickened by inflammatory tissue.

The operation performed was an ileotransversostomy with ileocolic tube drainage carried through a separate stab incision in the abdominal wall. The drainage tube was removed ten days after the operation. The patient left the institution in three weeks with both abdominal wounds healed.

Pathological Report. (Dr. Max A. Golzieher.) Diverticular ulcer and abscess of the wall of the cecum. The wall of the intestine is considerably thickened. This thickening is most conspicuous in the outer layers. The whole wall shows diffuse inflammatory infiltration of subacute type. In the center of the wall at about equal distance from the mucosa and the serosa there is a round cavity which is filled with fecal matter. The wall of this cavity is completely necrotic and the necrotic tissue is surrounded by an area of intense leucocytic infiltration. Some sections show remnants of viable tissue in the wall of this cavity and these remnants include also shreds of intestinal mucosa.

We are dealing with an intestinal intramural diverticulum with inflammation of the intestinal wall, partly of longer standing and partly of an acute gangrenous type.

Case II. A. R., a female, aged sixty-two, admitted to the Jewish Hospital, July 9, 1930.

Past History. Essentially negative.

Present History. Apparently there was no previous complaint referable to her present illness until four weeks ago. Since then the patient has been complaining of abdominal pains, especially on the right side. One week ago, she sought attention at the out-patient department for pain in the right upper quadrant. She remarked that she was losing weight and that lately she confined herself to a fluid diet. Yesterday an attempt to administer castor oil preliminary to a radiographic study caused violent abdominal cramps and vomiting. She could pass no flatus or stool and hospitalization was advised.

Physical Examination. A medium sized, somewhat emaciated female, acutely ill, groaning with pain. Abdomen, slightly distended, no visible peristaltic waves or distended intestinal loop were noted.

The abdominal walls were soft and flabby, the skin thin and lax. In the right lower quadrant a distended and very sensitive cecum could be distinctly felt. Only on deep and firm pressure was any tenderness in the right upper quadrant elicited.

Preoperative Diagnosis. Partial intestinal obstruction due to carcinoma of the right colon.

Operation and Operative Findings. July 11, 1930. Through a right rectus incision, an annular constricting neoplastic mass near the hepatic flexure was demonstrated. Glands in the contiguous mesentery were enlarged and seemed to be involved. The ascending colon and cecum below the growth were moderately widened.

A right hemicolectomy with an end-to-end ileotransversostomy was done. It was supplemented with an ileocolic rubber drainage tube, the end of which was brought out at the lower angle of the wound.

Notes. Two days of treatment preliminary to operation were extremely helpful. Colonic irrigations and warm abdominal stupes helped to relieve the obstruction. Gastric lavages relieved the vomiting and helped in part to decompress the gastrointestinal tract. Intravenous glucose solution, hypodermoclysis of similar solution helped to restore the fluid balance.

Postoperative Course. Several weeks after operation, a pelvic abscess that developed in the post cul-de-sac required a post-colpotomy. The patient was discharged four weeks later.

Pathological Report. (Dr. Max Lederer). Microscopic specimen 35 cm. of colon and 45 cm. of ileum. About 15 cm. below the ileocecal valve, there is a marked induration of the wall involving the entire circumference of the gut. On section the inner aspect of this mass is marked by an ulceration with heaped margins and roughened eroding base. The lumen is almost completely occluded by this mass. The lymph nodes on the serous coat opposite this area are firm. Examination shows the wall of the gut to be the seat of an unrestrained growth of intestinal glands which invade the entire muscular coat, extending to the serosa. The lesion is an adenocarcinoma of the colon. There is no microscopic infiltration of the sectioned lymph node by malignant cells.

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REDUCTION OF FETAL MORTALITY

IN AN OBSTETRIC SERVICE*

EDWARD SPEIDEL, M.D., F.A.C.S.

LOUISVILLE, KY.

AN unusually large percentage of fetal deaths in the obstetric service at the Louisville City Hospital during the year 1929 prompted us to make use of every available measure to have a better result in the following year.

We lost 142 babies in 1263 deliveries. Through proper deductions, absolutely nonviable babies, untreated syphilitics, toxemias of the mother and congenital anomalies, 82 could be eliminated, leaving 60 fetal deaths, a percentage of about 4.5, which will after all compare favorably with reports from similar institutions.

In order to reduce fetal mortality and especially to prevent stillbirths, every morbid condition in the mother must be detected and treated during her pregnancy.

An early examination in pregnancy should lead to the recognition of uterine displacements and by the use of a supporting pessary until after the fourth month, abortions on that account should be preventable.

Little beyond the recognized procedures can be done in saving the generally premature fetus in placenta previa and ablatio placenta as the loss of blood on the part of the mother is an additional factor in causing fetal mortality.

It should now be recognized that both conditions are absolute hospital procedures, which except in multiparae with well dilated cervices, demand cesarean section.

If the fetus is not too premature and in good condition it should have the benefit of a cesarean delivery rather than the certainty of absolute destruction when its body is used in the vaginal delivery as a tampon in order to assure a safe delivery for the mother. This is especially advocated in central and partial placenta previas as the operation renders the delivery safer for the mother as well.

If the vaginal route is selected in placenta previa and practically in the delivery of all premature babies, especially in primiparae, the principal cause of fetal death, cerebral injury, and intracranial hemorrhage, can be averted to some extent by the use of dilating bags to efface the cervix and of an episiotomy to remove the hazard of a tense perineum.

The present therapy of hyperemesis leaves but little to be desired in that direction and interruption of pregnancy with consequent fetal death should now occur very rarely.

At times, however, over-confidence in our therapy is rudely shaken, when a patient who has ceased vomiting and is taking an abundance of food presents sudden signs of collapse. We still have no reliable means of recognizing such extremely toxic cases. Very early interruption of the pregnancy might save them, but we have no criteria upon which to base the indication of the time for such a radical procedure.

Our therapy has been simplified considerably by the use of the Soresi blood transfusion apparatus and a thermos bottle outfit for the intravenous administration of glucose at a constant temperature and rate.

With proper prenatal care, the incidence of eclampsia can almost be eliminated.

It must not be forgotten, however, that with all our precautions, an indiscretion in diet on the part of a patient may precipitate

* Read at the Forty-fourth Annual Meeting of the American Association of Obstetricians, Gynecologists and Abdominal Surgeons, White Sulphur Springs, W. Va., September 14, 1931.

an attack. In practically all of our eclampsias we get the history of some dietary indiscretion. Pork chops, hot tamales, hot dogs, raw oysters, bacon and greens and lobsters figure in such recitals and although it is not claimed that such indiscretions are the cause of eclampsia, they certainly precipitate an attack in apparently healthy gravida.

It is claimed that in such instances digestion is interfered with, fermentation of the food products takes place and the toxins absorbed from the decomposed food with those already circulating in the system from the pregnancy, are sufficient to precipitate the eclampsia.

Especial stress accordingly should be put on dietary restrictions in the last months of pregnancy, to prevent eclampsia and fetal deaths on that account. Attention will also be necessary very soon to curb the excessive smoking and drinking of some of our young women, especially during the period of gestation.

In the late toxemias the placenta always shows extensive areas of white infarcts. These are practically inert areas in the placenta and if they are sufficiently extensive they interfere with fetal nourishment and may cause either fetal death or premature expulsion. Again, such devitalized areas are dead spaces in the placenta and the absorption of toxic products from such areas into the maternal circulation will result in fetal death.

This naturally brings up the question of delivery in toxemic patients. From the foregoing it is evident that even if the toxemia is apparently controlled in the mother, the life of the fetus is in jeopardy on account of the absorption of toxins generated by the infarcts of the placenta and the diminished functioning of the placenta due to such devitalized areas. It would seem, if the fetus is viable, that delivery should be instituted as soon as the mother is in a safe condition.

A great number of our fetal deaths were due to premature births in syphilitic women both treated and untreated. The fetal mortality was of course much greater in the untreated cases. It is advocated by some that a Wassermann test be made in every case of pregnancy. That is hardly practical in all circumstances. What is of more importance, it seems to me, is to gather statistics as to the condition five, ten and fifteen years after the birth of a living child from such a treated syphilitic mother, to determine whether it is a mentally and physically useful member of society or whether by our therapeutic measures we are simply bringing into the world morons, habitual criminals and physically unfit human beings. It is well also to learn that even in women who have had intensive treatment for syphilis throughout the period of pregnancy, the baby apparently free from taint at birth may show extreme symptoms of neurosyphilis one or two years later, as happened in a private case of mine. In plants and animals every effort is now being made to improve the stock by weeding out the unfit. It seems to me that it will soon be necessary to apply the same principle to human procreation. Given a syphilitic mother or father or both, the product of such a conception is surely impaired from the onset and when its physical being is once established, intensive treatment of the mother may prolong the period of gestation and give a live baby but it surely cannot remove the taint of its original inheritance. Nature has wisely decreed that if such cases of conception are left alone that the expulsion of an immature or macerated fetus takes place generally between the sixth or seventh month and we may well question whether our therapy is an improvement upon such destiny.

The very construction of the syphilitic placenta is such as to preclude the possibility of a living infant. The syphilitic placenta is larger, heavier and paler than normal, both the size and weight being due to edematous infiltration. The individual villi are larger and closely packed. The pallor is due to the obliteration of many blood vessels by thrombosis, and there is a

perivascular fibrosis which in time obliterates the vessels by pressure and accounts for the thrombosis.

Under the microscope syphilitic villi appear abnormally large, opaque and irregular in shape with swollen ends. The almost complete obliteration of the intervillous space, due to the increase in size of the villi, the inflammatory reaction in the intima and media of the vessels of the villi, the cellularity of the stroma and the apparent invasion of the stroma by the syncytial layer are all characteristics of the syphilitic placenta. Consequently the death of the fetus in syphilis is not due to the effect of the disease upon its organs, but upon the destructive changes produced by the syphilitic infection upon the structure of the placenta. It may also be presumed, then, that intensive treatment of the syphilitic mother during her pregnancy largely expends its force in preventing these destructive changes in the placenta making it possible for the mother to carry her syphilitic infant to full gestation.

Denmark has set the world a remarkable example of the efficient handling of the syphilis problem and it will be well for other nations to follow its precepts.

In my opinion the proper course to pursue at present is to inform the husband and the wife, that untreated she will give birth to a premature living or dead syphilitic fetus. That if properly treated she may give birth to a living child that will probably have syphilis. This cannot possibly interfere with any religious principles and will place the responsibility where it belongs.

A considerable number of fetal deaths will always occur from complications of labor. In breech deliveries improper extraction and twisting may result in fractures of the spine, injuries to the cord and suprarenal glands, and cerebral hemorrhage, all due to haste or wrong technique. In consequence external cephalic version is advocated by many in breech presentations. That has not been the custom in our clinic. Rather, have we tried to perform all steps in the delivery of such cases with gentleness and deliberation, taking plenty of time in bringing down the after-coming head, refraining from traction on the neck and aiding at once with the forceps if the after-coming head does not come down readily.

Forceps deliveries will account for many fetal mortalities. Premature infants should never be delivered with forceps as but slight compression of the soft head will initiate a cerebral hemorrhage. With the cervix properly dilated with a large Vorhees bag and an episiotomy when the head reaches the perineum, spontaneous delivery should be possible in all such cases. High forceps operations should be abolished. When the head will not descend into the pelvis with full dilatation then it is an indication of disproportion and it requires discrimination then to decide between a version and a cesarean section.

In middle and low forceps operations the safety of the procedure depends upon an accurate diagnosis of presentation and position, made by the location of the sutures and fontanelles and verified by the posterior ear. Then there should be a careful cephalic forceps application with extraction by careful, gentle traction in the proper direction, with release of the forceps blades between pains, to minimize cerebral injury.

In cases of contracted pelvis we have been over conservative and have lost a number of babies by conscientiously giving the mother a prolonged test of labor, when by an earlier cesarean section a living child might have been secured.

It is unfortunate that the real test of labor and the capacity of a given pelvis cannot be definitely determined until after full dilatation and rupture of the bag of waters and as is well known with each hour of such delay the prognosis for both mother and child is more unfavorable.

If we consider that in the best of circumstances the fetus, forced by nature through such abnormal passages, is subjected to the danger of more or less cerebral hemor-

an attack. In practically all of our eclampsias we get the history of some dietary indiscretion. Pork chops, hot tamales, hot dogs, raw oysters, bacon and greens and lobsters figure in such recitals and although it is not claimed that such indiscretions are the cause of eclampsia, they certainly precipitate an attack in apparently healthy gravida.

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In the late toxemias the placenta always shows extensive areas of white infarcts. These are practically inert areas in the placenta and if they are sufficiently extensive they interfere with fetal nourishment and may cause either fetal death or premature expulsion. Again, such devitalized areas are dead spaces in the placenta and the absorption of toxic products from such areas into the maternal circulation will result in fetal death.

This naturally brings up the question of delivery in toxemic patients. From the foregoing it is evident that even if the toxemia is apparently controlled in the mother, the life of the fetus is in jeopardy on account of the absorption of toxins generated by the infarcts of the placenta and the diminished functioning of the placenta due to such devitalized areas. It would seem, if the fetus is viable, that delivery should be instituted as soon as the mother is in a safe condition.

A great number of our fetal deaths were due to premature births in syphilitic women both treated and untreated. The fetal mortality was of course much greater in the untreated cases. It is advocated by some that a Wassermann test be made in every case of pregnancy. That is hardly practical in all circumstances. What is of more importance, it seems to me, is to gather statistics as to the condition five, ten and fifteen years after the birth of a living child from such a treated syphilitic mother, to determine whether it is a mentally and physically useful member of society or whether by our therapeutic measures we are simply bringing into the world morons, habitual criminals and physically unfit human beings. It is well also to learn that even in women who have had intensive treatment for syphilis throughout the period of pregnancy, the baby apparently free from taint at birth may show extreme symptoms of neurosyphilis one or two years later, as happened in a private case of mine. In plants and animals every effort is now being made to improve the stock by weeding out the unfit. It seems to me that it will soon be necessary to apply the same principle to human procreation. Given a syphilitic mother or father or both, the product of such a conception is surely impaired from the onset and when its physical being is once established, intensive treatment of the mother may prolong the period of gestation and give a live baby but it surely cannot remove the taint of its original inheritance. Nature has wisely decreed that if such cases of conception are left alone that the expulsion of an immature or macerated fetus takes place generally between the sixth or seventh month and we may well question whether our therapy is an improvement upon such destiny.

The very construction of the syphilitic placenta is such as to preclude the possibility of a living infant. The syphilitic placenta is larger, heavier and paler than normal, both the size and weight being due to edematous infiltration. The individual villi are larger and closely packed. The pallor is due to the obliteration of many blood vessels by thrombosis, and there is a

perivascular fibrosis which in time obliterates the vessels by pressure and accounts for the thrombosis.

Under the microscope syphilitic villi appear abnormally large, opaque and irregular in shape with swollen ends. The almost complete obliteration of the intervillous space, due to the increase in size of the villi, the inflammatory reaction in the intima and media of the vessels of the villi, the cellularity of the stroma and the apparent invasion of the stroma by the syncytial layer are all characteristics of the syphilitic placenta. Consequently the death of the fetus in syphilis is not due to the effect of the disease upon its organs, but upon the destructive changes produced by the syphilitic infection upon the structure of the placenta. It may also be presumed, then, that intensive treatment of the syphilitic mother during her pregnancy largely expends its force in preventing these destructive changes in the placenta making it possible for the mother to carry her syphilitic infant to full gestation.

Denmark has set the world a remarkable example of the efficient handling of the syphilis problem and it will be well for other nations to follow its precepts.

In my opinion the proper course to pursue at present is to inform the husband and the wife, that untreated she will give birth to a premature living or dead syphilitic fetus. That if properly treated she may give birth to a living child that will probably have syphilis. This cannot possibly interfere with any religious principles and will place the responsibility where it belongs.

A considerable number of fetal deaths will always occur from complications of labor. In breech deliveries improper extraction and twisting may result in fractures of the spine, injuries to the cord and suprarenal glands, and cerebral hemorrhage, all due to haste or wrong technique. In consequence external cephalic version is advocated by many in breech presentations. That has not been the custom in our clinic. Rather, have we tried to perform all steps in the delivery of such cases with gentleness and deliberation, taking plenty of time in bringing down the after-coming head, refraining from traction on the neck and aiding at once with the forceps if the after-coming head does not come down readily.

Forceps deliveries will account for many fetal mortalities. Premature infants should never be delivered with forceps as but slight compression of the soft head will initiate a cerebral hemorrhage. With the cervix properly dilated with a large Vorhees bag and an episiotomy when the head reaches the perineum, spontaneous delivery should be possible in all such cases. High forceps operations should be abolished. When the head will not descend into the pelvis with full dilatation then it is an indication of disproportion and it requires discrimination then to decide between a version and a cesarean section.

In middle and low forceps operations the safety of the procedure depends upon an accurate diagnosis of presentation and position, made by the location of the sutures and fontanelles and verified by the posterior ear. Then there should be a careful cephalic forceps application with extraction by careful, gentle traction in the proper direction, with release of the forceps blades between pains, to minimize cerebral injury.

In cases of contracted pelvis we have been over conservative and have lost a number of babies by conscientiously giving the mother a prolonged test of labor, when by an earlier cesarean section a living child might have been secured.

It is unfortunate that the real test of labor and the capacity of a given pelvis cannot be definitely determined until after full dilatation and rupture of the bag of waters and as is well known with each hour of such delay the prognosis for both mother and child is more unfavorable.

If we consider that in the best of circumstances the fetus, forced by nature through such abnormal passages, is subjected to the danger of more or less cerebral hemor-

rhage, it may justify us in prompter resort to abdominal delivery when pelvic measurements and high riding of the fetal presenting part indicate at least a difficult vaginal delivery.

Abnormalities of the umbilical cord will at times lead to disaster. The short cord will indicate its presence by delay and recession of the presenting part after each pain in the second stage of labor. It may lead to premature separation of the placenta and fetal death unless prompt measures are instituted to terminate such a situation. In prolapse of the cord the patient should at once be placed in the Trendelenburg position, over the rungs of a chair placed on the bed if the condition occurs in a private house. This generally removes the pressure of the presenting part upon the cord and circulation in its vessels is reestablished. Further steps in the delivery can meanwhile be carefully planned.

Every now and then a baby is born which, after resuscitation seems to breathe with difficulty and presents signs of venous congestion, the so-called "blue baby." The general belief has been that this was due to delayed closure of the foramen ovale but now we learn that it may be caused by hyperplasia of the thymus gland. Apparently sudden engorgement of this gland may result from too vigorous attempts at resuscitation, especially bending and twisting the newborn baby to make it breathe, together with rough wiping of the throat to remove mucus. The actual cause of death in these blue babies can of course only be ascertained post mortem, and it will be well in the future for obstetricians to regard thymus engorgement as a cause for the calamity.

According to Henderson a great many infants are lost at birth and in the two weeks following from atelectasis. Examination of the lungs post mortem often shows areas of improper expansion. Accordingly it is advisable that all the older and cruder methods of resuscitating an asphyxiated infant, such as hot and cold dipping, spanking, slapping and swinging, be abolished. In place of these, reliance should be placed on gentle mouth to mouth breathing and the inhalation of a mixture of 93 per cent oxygen and 7 per cent carbon dioxide, as it has been found that the carbon dioxide is the essential stimulant to respiration. This special mixture is available in the market together with an infant's inhalation apparatus with a gas bag and inflatable mask wherewith the administration is exceedingly simplified.

Henderson is so impressed with the value of this procedure at birth and in the early succeeding days, that like the Crede eye treatment, he claims that it should be made compulsory, that every child whether asphyxiated or not be given the benefit of such a treatment for ten minutes several times a day in the first week of its life.

Postnatal pneumonia will account for a large number of fetal deaths. In premature rupture of the bag of waters the baby is in danger from inspiration of infected liquor amnii, the colon bacillus being the most frequent factor. Infection may similarly occur when the head is born and the mouth rests in close proximity to the anus. It follows accordingly that no vaginal examinations should be made in cases with premature rupture of the bag of waters as the baby is in sufficient danger from the microorganisms that can naturally gain entrance to the uterus if the labor is prolonged without having additional germs implanted by the examining fingers. Furthermore, care should be taken to keep the perineum and the anus free from fecal matter at the expulsive stage of a delivery.

Every hospital should be provided with the oxygen carbohydrate apparatus for resuscitation of asphyxiated infants and for the treatment of atelectasis and pneumonia after birth. It may perhaps be unreasonable at present to expect every practitioner to carry such an apparatus with him in home deliveries. He should, however, always be prepared to give immediate assistance to the asphyxiated and narcotized baby. Nearly all physicians now use some form of analgesia in the

conduct of labor cases and in consequence a differentiation must be made between a narcotized and an asphyxiated baby. The narcotized baby as a general thing is blue and makes no effort to breathe. Fortunately in most of such cases respiration can be induced by the intravenous injection of an ampoule of alpha lobelin. The umbilical cord is the most convenient site for the injection in the baby. The injection should be given into the umbilical vein and the vein can best be recognized by the fact that its course is straighter than that of the umbilical arteries, furthermore the umbilical arteries pulsate. A varicosity of the vein on the outside of the umbilical cord is selected about 4 to 6 inches from the vulva and the alpha lobelin injected with an ordinary hypodermic syringe. This procedure with proper removal of the mucus from the throat, gentle mouth to mouth breathing and keeping the baby warm should prove efficient in most cases of asphyxia and narcosis in the home.

Finally there is the class of cases where the fetus can carry on an intra-uterine existence, with respiration, nutrition, excretion and circulation through the placenta and umbilical cord, but which is absolutely unfitted for postnatal existence on account of abnormalities in development. In such cases the fetal heart will have been heard throughout the delivery and yet an apparently deeply asphyxiated baby will be born, perhaps after an unusually easy labor, that does not respond to efforts at resuscitation. Three cases of that kind occurred in our experience. The one after an easy cesarean section showed an imperforate anus and upon postmortem examination, transposition of all the viscera. The left side of the diaphragm was absent with the heart and lungs crowded to the right and the stomach and small intestines pushed up to the clavicle. The second case was on the same order with the exception of the imperforate anus. The third had congenital cystic kidneys with atresia of the ureters. It follows that in all obscure fetal deaths in uncomplicated deliveries the physician should demand a postmortem examination or at least the possibility of an abdominal inspection and if such an abnormal condition presents itself then it will be a full exoneration of the attending obstetrician in what would otherwise be a very annoying and disheartening occurrence.

In spite of especial care in the conduct of our cases at the Louisville City Hospital we have to report for the year from July 1930 to July 1931, 138 fetal deaths in 1471 deliveries. Of these fetal deaths only 42 were full term, 96 were premature with 38 non-viable. In addition 31 fetal deaths were due to syphilis.

Fifty per cent of the fetal deaths accordingly were beyond our control. Other public institutions of a similar character no doubt have about the same mortality.

Therefore, while we should make every effort to reduce fetal mortality, yet the profession should no longer subject itself to criticism by the medical and lay press from the constantly repeated statement that 200,000 or more babies are lost each year in childbirth and that we rank seventeenth among the nations on account of our obstetrical mortalities, without explaining that fully 50 per cent of the fetal deaths are due to premature, non-viable, syphilitic, and macerated, fetuses, and other unavoidable fatalities, including a large percentage of abortions, which no amount of obstetrical skill or attention can lessen or prevent.

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COMMENTS ON

TORSION OF THE ADNEXA

WITH A REPORT OF ILLUSTRATIVE CASES*

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IN the past six months various interesting cases of adnexal torsion have come to our notice in the University of Chicago Clinics. On account of the supposed rarity of such lesions we have considered them in some detail.

INCIDENCE

It is interesting to notice how the literature has been characterized by groups of reports, as for example, those that followed the papers of Schweitzer and Ruder in German and Davies in English. When attention is called to the possibility of torsion more examples are found. Many cases have been unreported, as Battey mentioned in discussing the paper of Munroe. The same comment was made by Bloomer, Gale, and Rogers. Eastman remarked on the frequency of these cases in a rather small clinic. Anspach reviewed a large number of reported cases in 1912 and remarked that many references had escaped him. Forty-four authors have reported more than one case, of whom the best examples are Lejars with 8 cases, Hammerschlag with 5 cases, Gengenbach with 6 cases, Bass with 11 cases, Michon with 5 cases.

The diagnosis may be difficult and make recognition very hard. Some cases have had absolutely no history of lower abdominal distress (our cases II and V, Haultain's cases I and II, Mauclaire's case and Siredey's case). The distress may be very trivial (Michon, case V). There may be only a mild dysmenorrhea whose distinctive characters, if any, are overlooked (Gueillette, Gabe, Auvray case II, Pozzi case III, Fuchs, Tourneaux cases I and II). The torsion may be very temporary and so the attack of pain be very brief. Some surgeons have found the torsion uncoiling spontaneously (Wachtel case II, McIlroy, Miles). Rogers found a pair of twisted tubes of which one was in such good condition that it could be untwisted and left in situ. Some cases are found only at autopsy accidentally, as in our Case II and many of the earlier cases reported, e.g., Morgagni, von Rokitansky, etc. The latter alone found fifteen such lesions at autopsy.

On the other hand a typical distress may develop, last only a few hours, and then disappear for hours to years (Stark, Michon case V, Laurent, Kohler, Schreiner, Chabrut, Fuchs, Roll, Cassidy and Norbury). Well over one-third of the patients have had symptoms of some sort for a considerable time. The attacks may go on as long as nine years (Martin), or eight years (Michon case I). Anspach, in his collected cases, 87 in number, observed that 56 had had symptoms for two weeks or more, but 9 for thirty-six hours or less.

Probably many cases have been missed even at laparotomy. For example, Aulhorn's case and Gengenbach's case IV both suggested ectopic pregnancy at first sight. Hematosalpinges, ovarian infarcts, hemorrhagic ovarian cysts or ovarian pregnancies are very difficult to differentiate largely because torsion is so often followed by the formation of hemorrhagic or infarcted tissue. Many operators have used right sided incisions and have, therefore, explored the adnexa by touch rather than sight. This would prevent the diagnosis of slight degrees of torsion at least

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(Darner). In many clinics insufficient study of the operative specimens has been responsible for missing these lesions.

It seems difficult, therefore, to estimate the real frequency of adnexal torsion, but it probably is much commoner than has been supposed. The torsion of ovarian cysts, as in our case v, is extremely common; Martin estimated 5 per cent of ovarian cysts twisted and Kustner 47 per cent; but perfectly normal adnexa may undergo torsion and probably often do. Moreover such etiological factors as are discussed in this paper are so frequent and the symptomatology of these lesions so variable that it is doubtful if we diagnose more than a few of the actual cases.

CHARACTER OF TORSION

The degree of torsion seems to have very little clinical significance as Michon observed in his first three cases (Haultain, Norris, Stein, Paucot and Meurrise, Wachtel). Haultain's case III had symptoms for four years which may or may not have been due to torsion but which, however, suddenly became extremely acute. At operation the left tube and ovary were found twisted only two-thirds of one turn. Many cases have undoubtedly had many turns for years without symptoms, as already mentioned. Some of these have had one more suddenly added to produce the characteristic group of symptoms the others had failed to excite (Bell, Grosse). Possibly the factor producing pain is not torsion at all but rather a hemorrhage into the muscle wall especially under the serosa (Ogorek, Michon). The presence of hemorrhage or infarction usually dominates the picture in cases where pain has been a symptom. We can see how the circulation in a loosely twisted mesosalpinx or ovarian ligament may be competent till a minimal additional torsion will produce widespread congestion with rupture of the vessels and the sudden characteristic onset of pain due to hemorrhage.

Considerable attention has been given to the direction of the torsion. Schauta believed that right-sided pedunculated bodies twist to the right and left-sided bodies to the left when torsion occurs. The data in many of the earlier reports, especially, is incomplete in this regard. There has been a very loose terminology also (see Küstner, Lippert, and Schauta's comment on Küstner) and obvious misuse even of such terms as clockwise and contra-clockwise. But assuming that the plane of reference is the mid-plane of the body and that the observer is looking outward along the tubes toward the ovaries in orienting these torsions, we have tabulated all the reports of otherwise normal adnexa found. By normal adnexa we mean the few where histological examination demonstrated normality and some cases in addition where there was a balance of evidence for normality, e.g., a history of several normal pregnancies. We found that there had been torsion of the right tube 60 times and of the left 28; of the right-sided torsions 7 out of 15 were clockwise, in the left, 6 out of 12 were clockwise. On the same basis the number of normal ovaries reported with torsion is 35, 15 on the right and 10 on the left. Apart from Smith's and Butler's report on ovarian torsion only one mention is made of the direction of the twist (Wachtel). Smith and Butler, however, found that Küstner's law as interpreted by Schauta, and by Downer and Brines, usually held. It seems to us that the general validity of Küstner's law is very doubtful for the adnexa, certainly as far as tubes are concerned. There is, of course, a very obvious preponderance of right-sided torsions as will be discussed later.

LATERALIZATION

As already mentioned the ratio of right to left sided torsions of normal or probably normal tubes is 60:28, of ovaries 15:10. This is very close to the figures given by Anspach, etc. for unselected groups. The presence of the sigmoid wedging the contents of the left pelvis in place, the peristalsis of the small

bowel on the right (Woollcombe) and the presence of the adjacent appendix (Thorek) have been used to explain this right-sided predominance. A great many of these specimens are secured at operations aimed at the appendix. Symptoms which in the right lower abdomen would frighten a surgeon into immediate operation seem much less alarming when on the left; hence, the latter are treated conservatively, subside, and are often undiagnosed. Moreover, should operation be done the left adnexa are too far away from right-sided incisions to receive satisfactory attention. These things may be real factors in the reported incidence.

More important in this right-sided incidence may be the predominance of right-sided use of our bodies. We use our right limbs oftener and more violently. Our right shoulders droop and when we lift we compress the abdomen more on the right because more weight is born by the stronger muscles. Objects we hold are usually steadied by pressure against the right abdomen. Zikmand (see Horsch) made the interesting observation that in 1913 only 13 per cent of ovarian tumors were twisted as against 25 per cent in a similar series collected in 1916, and he ascribed this largely to the increased muscular activity of heavy war work. Tenckhoff (*loc. cit.*) ascribed the torsions largely to symmetrical pelvic motions: Spasmodic acts such as laughing, sneezing, etc. may be factors in causation but not in lateralization. Schreiner had a patient whose first attack occurred while carrying a two-year old child, and the second attack a year later while scrubbing clothes. It is to be noted that the tendency to right lateralization is more marked for ovaries than tubes probably because the latter are closer to the midline and on movement have a smaller arc and acquire less acceleration.

SPONTANEOUS AMPUTATIONS

In 1914 Ogorek collected 97 cases of spontaneous adnexal amputation, of which 27 were discovered at autopsy and 73 were complete. The autopsy cases began with Morgagni in 1748 and ended with von Baumgarten in 1892. There have been 24 cases of complete or incomplete spontaneous amputation reported since Ogorek's papers appeared, bringing the total number in the literature up to 122. Ours is the 123rd. The cases added have been those of Schweitzer, Hirsch, Robinson, Cotte, Grosse, Bass, Gengenbach, Michon, Spencer, Michon and Comte, Küstner. In only half of these was the amputation complete. Of the complete amputations 8 involved the right adnexa and 8 the left. The accidents were generally ascribed to tubal torsion.

The amputated portions may be one or several organs. The site may show no scarring as in the case of Michon and Comte and our case II, or may show definite scars as in Michon's cases I and II. Braun had a case of unilateral torsion of the adnexa in which no trace of scarring could be found one year later (see Menge and Oettingen). Only the demonstration of the interstitial part of the tube proved what had happened.

Such accidents may be symptomless. The amputation may end with calcification of the amputated portion or degeneration and complete resorption. As no trace of tube was found in our case it was probably completely resorbed. Amputation may be bilateral (Michon and Comte, Ries, Albertin). The cases of Michon and Comte, and Albertin were only recognized on careful examination of the specimen although the amputation was complete. Intra-uterine torsion and torsion in the first week of life were reported by von Rokitansky and von Heschl, von Rokitansky and Fraenkel (see Ogorek).

There may be no pain or there may be sharp and sudden pain. The pain may subside for years only to recur and subside as before (Ogorek, case II); there may be severe dysmenorrhea for as long as ten years although the lesion seems healed at operation (Michon, case I).

The diagnosis is from congenital anomalies, ruptured ectopic pregnancy or gumma. Congenital defects are usually accompanied by genitourinary anomalies or uterine malformations. A good survey of the subject is given by Menge and Oettingen, also by Michon.

TORSION OF NORMAL ADNEXA

Anspach and Thorek have cast doubt on the authenticity of such lesions. They remark that childhood exanthemata may produce chronic involvement of the internal genitalia and that early vulvovaginitis may persist for years. It is difficult to combat this point of view as histological findings after operation are confused by the aseptic inflammation attendant on torsion as well as the massive hemorrhage which destroys or masks the tissue structures. Many authors have reported hematosalpinges as normal tubes, assuming they could differentiate primary from secondary hematosalpinges. Anspach cites the cases of Funke and Hennig of tubal lesions in virgins after "typhus," and Almartine's torsion of the tube in a tuberculous virgin. A lesion may be in an incipient stage and so not be diagnosed at operation. For instance, Anspach operated on a right pyosalpinx and re-operated on the same patient two years later, only to find a tuberculous salpingitis on the opposite side. A tube may seem to be quite normal, free of adhesions and patent, but be tuberculous on microscopic study (Gery and Lacoix). Few authors have studied their tissues histologically and so the judgment of the remainder may be faulty. But in those cases in which we have a recognizable tissue for examination soon after torsion occurs and can find in it no evidence of acute or chronic inflammation, we may assume the tissue normal. Any other attitude is hypercritical.

We have found fairly good evidence that the tubes involved were normal in 53 cases reported. About half of these have no microscopic reports; some were removed during gestation and were congested, etc. But we have excluded only those cases where there was some reason to suspect infection or the interference of adjacent masses. These reports begin with Stark and Schweitzer and end with the recent ones of Michon, Walawelski, Cotte and Gengenbach. This excludes cases of spontaneous amputation simply because so many of these showed too much degeneration to estimate if normal conditions preceded the accident. We also found about five reports of the torsion of normal ovaries since Smith and Butler collected their cases in 1921. (Of course, many of their cases were not normal by the criteria mentioned above.) Our own case IV should be added here. Many of these so-called normal adnexal torsions gave histories of prolonged and characteristic symptoms and on histological study might very well have shown tissue changes which would have precluded their inclusion on this list.

ETIOLOGY

This is a vexed problem. The usual long list of traumatic causes have been adduced. No experimental work has been done except the indirect studies of Payr and Sellheim.

Probably the foundation is laid in fetal life. The presence of tightly coiled spirals in fetal tubes and infant tubes is common knowledge. Spuler remarked that as the body of the fetus grows the tubes stretch and later elongate. The ovaries, however, come closer to the fundus uteri. As the tube is considerably longer than the overlying peritoneum, it assumes convolutions or spirals. The discrepancy between the tube and its overlying peritoneum persists to about puberty at least and is common even in adults. Auvrey believes that actual fetal spirals may persist. Vigholt quotes Hess as saying that 30 per cent of adult tubes show infantile characteristics. In a series of 25 autopsies on female infants, done during the course of this study, all of them from six months gestational age to two years, we found 7 cases of complete single or double spiral twists of one or both tubes. In 4 cases the right tube was

involved, in 3 cases the left. In all of the latter the spiral was contra-clockwise; in the 3 right-sided cases in which it was recorded it was twice clockwise and once contra-clockwise. These figures are somewhat suggestive.

Probably these spirals develop in fetal life if the ovary's descent is very rapid or the tubal portions unusually elongated or elastic. Most twisted tubes reported in both fetuses and adults have been disproportionately long. The corpus uteri is markedly anteflexed in the young fetus. This anteflexion throws the anterior half of the first coil of the tube forward and so gives the initial impetus to contra-clockwise coiling on the left and clockwise on the right side. This tendency persists in succeeding coils since it is so difficult to reverse the direction of any spiral once it is under way. In 2 of our cases, including the illustrated one, there was a marked anterior rotation of the corpus uteri on the same side as the twisted tube. Fuchs reported a case of twisted hematosalpinx which he ascribed to congenital convolution of the tube producing obstructions and later aseptic inflammatory obstruction. Spuler remarks that the tubal ostia are often closed in the newborn; that as early as the 30 mm. embryo we can see swelling of the fimbriae and these may close the ostium in late fetal life or in the newborn. There may be the same tendency in the plicae of the tube, producing the diverticula, and pockets in the mucosa that are found in adults.

Many torsions have been reported before puberty (Neugebauer, Wachtel, Munroe, Roll, Fiolle, Downer and Brines). Roll's cases were in two sisters, aged seven and one-half and eight years respectively. There have been cases of tubal torsions after the menopause (Gengenbach, Borner, Grossman). These last 3 cases were in abnormal tubes, however.

The relation of trauma to these incidents seems very definite. All trauma applied to a pelvic organ is tangential and so has a twisting moment (McIlroy and Bass). Often the symptoms begin immediately after an unaccustomed trauma. For example, reports are to be found of torsion following carrying a child, scrubbing clothes (Schreiner), shoving a stalled car, and lifting (Kohler), sports (Rogers, Ruder and Hansen), a kick in the belly (Darner), washing (Borner, Ogorek), sweeping (Norris), stooping (Dearborn). Anspach reported such causative trauma as sitting down too hard, suddenly rising from a seat, falling on the street, a long walk, riding in a street car, cranking an automobile, and defecation. Zikmand (Horsch) made the interesting statistical observation previously mentioned. Sellheim actually produced torsions in bed-patients (in one case of 3½ turns) in 2 cases which had ovarian cysts, by rotating them and suddenly stopping the rotatory motion.

On the other hand many cases have come on suddenly out of a clear sky; in some of these no trauma could possibly have been causative. Martin's patient had her first attack in the middle of the night. Bass' case 1 was of a woman three months pregnant whose first attack came on suddenly in the night. Corlette's patient had been in a hospital bed twenty days when the pain suddenly began. Michon's case v recurred suddenly at night after a two-year period of freedom.

Unusual laxity of the supporting ligaments and unusual length of the viscera themselves have been considered an important factor by a great many authors. None of our cases had this characteristic, and we think it is of very secondary importance. If a tube or ovary is about to twist, it will twist whether or not it must first turn the whole broad ligament or adjacent adnexa. Ogorek cites instances of tubes as long as 36 to 76 cm. Bittman found that the opposite tube was very long and the twisted one very infantile (which was probably much more to the point). Vigholt remarks that in one case reported the mesosalpinx on the side affected was four times as long as its mate opposite. An abnormally long supporting

ligament prevents replacement when torsion occurs (Douglass). Muir's case occurred (after dancing) in a woman who had had an unrepaired prolapse of eighteen years' duration.

Another debatable etiological factor is inflammation. J. L. Faure in discussing the paper of Rocher and Jeanneney remarked that a pliable normal tube should twist more easily than a thickened inflamed one. Anspach believed that adhesions were conservative measures and yet reported a case of torsion of a tube containing pus and showing adhesions. Bloomer, Gale, Miles, Gabe, Bell held that adhesions were definitely a conservative measure. Michon suggested, however, that adhesions were etiological factors. Pozzi's case I showed no appendix but the site of the appendix on the cecum was adherent to the twisted right adnexa. His case II showed some pus on the right side of the pelvis at the time of an operation for right ovarian torsion. Thirteen days later re-operation showed free pus in the pelvis and torsion of left adnexa. Both excised tubes showed similar lesions. Sellheim, in discussing Hornung's paper, emphasized the ability of the blood stream to untangle a torsion that has just occurred unless a strong force maintained the displacement.

Tenckhoff (see Horsch) emphasized that in symmetrical movements of the pelvis the organs tend to lag a little behind the pelvic rotation. Friction of the belly wall tends to prevent torsion. The thinner the fluid content of an organ, the more independent it is of movements impressed on it by its enclosing wall, and hence torsion occurs more readily. The freer the swing and the larger the mass the greater is the arc described. By experiments with raw and partially cooked eggs, with the fetus in an intact amniotic sac, and on patients with ovarian cysts, he showed how the sudden stoppage of rotatory movement caused torsion.

Haim, Michael and Guibal, Gengenbach, Mandelstamm, Bass have reported cases of torsion in the puerperium. If laxity of supporting structures were important, accidents of this sort should be common. Moreover, changes in intraabdominal pressure should then be most rapid and most marked. Some twenty-one authors have reported cases of torsion during pregnancy. There are 5 cases reported of torsion of tubal pregnancies, viz. LeBalle, Charbonnel and Favreau, Pozzi case III, Martin, and Freund Jr. (for latter two see Littauer). LeBalle reported a tubal abortion on one side with a twisted pyosalpinx on the other.

It is very significant to observe the relation of torsion to the menses. Of course, cases have occurred in children before puberty, and in 3 cases in the menopause (see foregoing). But the great majority of the cases are strikingly related to menses. For example, some 21 reports since 1900 have commented on this characteristic. Notable among these are the cases of Grossman, Davies, Rogers, Allen, Darner, Miles, Terruhn, Torland, Casagrande, Vigholt, Gueillette, Gabe, Hammerschlag, Walawelski, Auvray cases I and II, Pozzi cases I and III, Morel, Norris, Fuchs, Tourneaux, Michael, Wells, Holtmann, Michon, our own cases III and IV. There seems no doubt that this accident tends to occur at or near menstruation. Chaput reports 2 unusual cases of young women who had had no menses and so had in the course of years developed hematocolpos and hematoperitoneum. Both had imperforate hymens. These were ruptured and the patients each died in a few days in coma. At autopsy the tubes were found enormously enlarged and in each case one tube showed torsion.

The importance of tubal peristalsis was expressed by Mauclaire. Cahen found the contractions of tubes in animals were short and regular in the dioestrus, but strong and slow after oestrus. He quotes Keye who puts the augmentation of uterine contractility at about the tenth day after dehiscence. Hartman found increased motility during the migration of the ovule. Seckinger and Snyder found in portions of

excised tube muscle that there was an increase in the rate and size of the contractions in the premenstrual phase and that the rate was even more rapid in the early interval stage. Kok quotes Thorn who noted the expulsion of tubal pregnancies by painful peristalsis and antiperistalsis. Mickulicz-Radecki remarked that the motility of the human tube varied greatly. He saw very strong contractions with contraction intervals up to five minutes in length in a tube removed on the second day of a period and three tubes of ruptured tubal abortion; these were especially strong in the tubal abortion. The maximum shortening was 2 cm. (in a 12 cm. tube). A tube on the first day of a period showed very poor contractions and the same was true of two badly damaged tubes from tubal abortions. Almost all the tubes contracted in a similar rhythm, about fifteen to forty-five seconds at a time. No difference was found for tubes taken in the interval days, during pregnancy, or in senility. Where there was fresh inflammation or in atrophic or anemic tubes there were no, or scarcely any, spontaneous contractions. The intensive contractions at menses or in tubal abortions were explainable by the increased size of the tubal content acting as a foreign body as it would in the gut. Darner quotes a personal communication from Guttenmacher who found violent and irregular contractions in the tubes of the pig before sex maturity.

Certain individuals, perhaps a very high percentage, have some persistence of the long thin-walled infantile type of convoluted tube. Spirals in such tubes are relatively frequent. In early life the inherent motility of smooth muscle begins to display itself and probably increases toward puberty. Thereafter it is strongly accentuated before and especially just after menstrual periods: it also persists after the menopause. This motility is increased by mild inflammations locally, by congestions or traumata producing aseptic inflammation, and by menstrual congestion. However, if the inflammation progresses to the stage where the tubal muscle or blood supply is injured there is a marked decrease of peristalsis and antiperistalsis. The early formation of adhesions is a complicating factor, for this induces stasis, local infarctions, and thromboses, all of which are elements of a vicious circle and tend to maintain the viscus in its new locus. Until such adhesions form, the force of the blood stream largely serves to right any malpositions that develop. At the same time perhaps there are obstructions in the tubal lumen. These may be due to a persistence of fetal agglutination of fimbriae or plicae, or to the regurgitation and exaxial lodgement of clot or endometrial fragments from the corpus uteri. Whatever the obstruction, there is a corresponding increase of tubal peristalsis. The peristaltic waves must now travel over a muscle wall of varying conductivity and contractile power. This variation is probably due to inflammations or to congenital distortion as already mentioned. In any case, the irregular front of the advancing peristaltic wave coming to a point of obstruction creates a twisting moment about the tubal axis. This is very well demonstrated in tubal ectopics such as we have cited. In them the increased motility of both tubes which results may produce a torsion of the unimpregnated tube and this may occur even in spite of factors producing adhesions such as acute inflammation, free pus and blood in the pelvis. Even if the walls of the tubes are materially damaged by enormous distention one may still have torsion produced as soon as peristaltic activity has an opportunity to empty them. Küstner's law does not seem to apply to normal or relatively normal tubes.

Contributing factors in adnexal torsion are unusual length of the structures involved or their supporting ligaments, a thin or infantile type of pedicle in the organ itself and some exciting external trauma. As these latter factors are largely right-sided in a right-sided species, the

greater proportion of these lesions are found on the right side of the pelvis. All external trauma applied to smooth-walled viscera is tangential and so has a twisting moment.

These traumatic and architectural features are much more important in organs like the ovary which are comparatively free and distinctly lateralized. These have a correspondingly greater tendency to right-sided incidence. They show more tendency to follow Küstner's law because their tissue is denser and has a specific gravity sufficiently great to admit the play of gravity, something a hollow tube scarcely allows. Moreover, cysts of some sort or other are so frequent in the ovary that Sellheim's mechanism becomes applicable and the fluid contents of these cysts explains much of what happens. Payr's mechanism has something to contribute to torsions in any of the adnexa but, of course, merely initiates changes. Payr himself could under the most favorable conditions in isolated organs produce only 180 degrees torsion by its means. However, it may retain an organ in an abnormal situation long enough for other factors, such as light adhesions, thromboses, etc., to maintain and increase the torsion already begun.

Laxity of ligaments and pedicles cannot be accorded very much importance, or puerperal torsions would be the rule rather than the exception. Probably the adnexa involute at least as rapidly as the corpus uteri and hence are not loose but fairly taut throughout the puerperal period. Torsions during pregnancy may be due to fetal movements, displaced gut, etc., but are, on the whole, inhibited by the enlarged uterus which occupies most of the available space in the pelvis, and keeps the adnexa fairly taut.

It seems likely that inflammation plays a double role, inciting torsion by increased peristaltic activity and obstructions, maintaining any torsions that occur, favoring congestions, thrombosis and stasis. But when acute and severe it damages the tube so badly that tubal motility is impaired and adhesions are rapidly formed to maintain the viscera in situ. In passing we might note that Chaput and others have had cases of tubal torsion where both ends of the tubes were fixed by adhesions. These are difficult to explain.

SYMPTOMS

This topic has been well discussed recently in English by both Darner and Koster. The symptoms range all the way from those of mild dysmenorrhea to those of an acute abdominal emergency, with vomiting, intestinal obstruction and such agonizing pain as only morphia can control. There is often a history of recurrent attacks, usually with a definite relation to menses, and dating back to an important abdominal trauma or rhythmic movement. If right-sided the case presents features very like those of appendicitis but rectovaginal examination will usually determine the true nature of the situation and if the case is held over the symptoms rapidly subside. Occasionally leucocytosis and fever occur, but this is rare. Two of our cases showed considerable dyspareunia.

DIFFERENTIAL DIAGNOSIS

This also has been well discussed by the last named authors and very many others. The principal differentiations are from appendicitis and ectopic pregnancies. Nearly all the early cases were operated on for appendicitis. When mistakes have been made they have usually been directly traceable to the omission of rectovaginal examination. The characteristic history of a sudden onset after trauma, recurrent attacks related to menses or traumata, and the tendency to complete temporary bowel obstruction are great helps to diagnosis.

TREATMENT AND PROGNOSIS

It has been generally held that the proper treatment for cases of adnexal torsion was immediate laparotomy, or laparotomy as soon as possible after the acute phase was over. It has been shown repeatedly that if the diagnosis has been

made to one's satisfaction it is safe to let the patient alone for weeks or even a month or more until the tenderness, pain and fever have reached a minimum. If one is uncertain about the differential diagnosis no harm is done by immediate intervention. If no such intervention occurs the body can handle the situation fairly well, but symptoms of discomfort of varying degrees with periodic recurrences continue for years, and in the end most of such cases necessitate operation anyhow. Where such cases are left alone spontaneous amputation and resorption occur, or progressive torsion develops with eventually even gangrene, or dense protective adhesions ensue which wall off the lesion. On the other hand, as mentioned in the foregoing discussion, the torsions may untwist and it is very probable that many transient pelvic pains are produced in just this way and never are diagnosed, much less come to the operating table. We would like to emphasize that this possibility should always be borne in mind in abdominal diagnosis.

We must thank Dr. F. L. Adair for permission to publish cases I, IV, V and VI, and Dr. H. G. Wells for the same privilege in cases II and III. It is a pleasure to acknowledge Prof. Adair's accustomed courtesy in assisting with the preparation of this report.

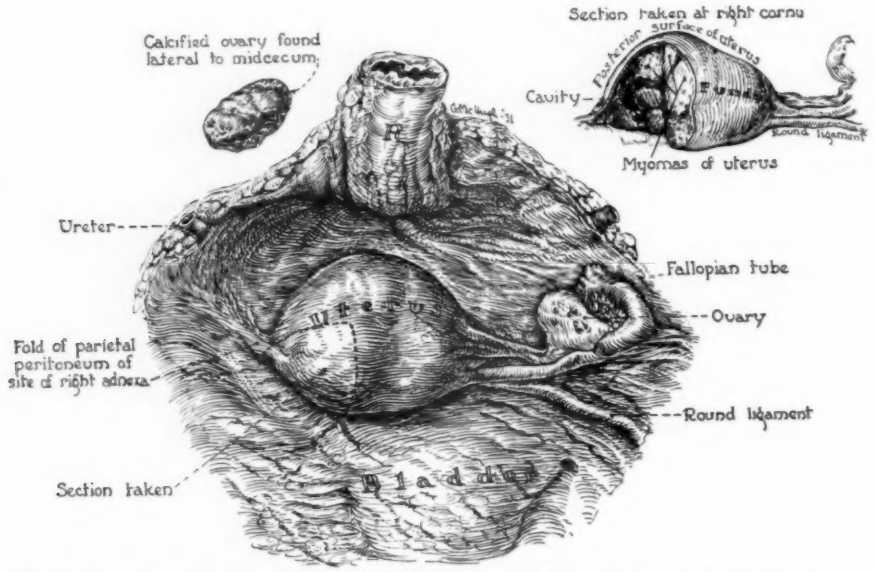

FIG. 1. Case II. Spontaneous amputation of right adnexa in an adult. One insert shows amputated ovary and other shows a section through fundus uteri at right cornu.

CASE I. Miss G. H., No. 21731. Age 41.

Three years before admission the patient noticed a soft moveable mass in the lower abdomen. This had doubled in size since it was first noticed. She suddenly developed lower abdominal pain on April 10 and the following night the pain was excruciating. When examined on the fifth day of the attack there was a midline mass in the abdomen the size of a grape fruit and movable. A little to the left was another mass firmer in consistency. The last menstrual period had ended seven days before the attack began; the periods of the last five months had been irregular. The preoperative diagnosis was a fibroid on the anterior left side of the uterus and a right pedunculated ovarian cyst. There was a slight fever; and the white blood cells were 10,000 on admission.

At operation on April 18 the left adnexa were found normal. On the right there seemed to be a gangrenous ovarian cyst with two complete twists involving tube and ovary. No adhesions were seen.

A careful study of the excised specimen showed that the cyst was a large parovarian cyst, 10 cm. in diameter. The right tube was adherent to it and stretched over it in such a way that its distal end was immediately

adjacent to the uterine cornu; some of the fimbriae, indeed, had separated from the ostium and attached themselves to the isthmic portion of the tube. At its distal end this tube was closely adherent to the ovary and both were twisted clockwise through 360 degrees. The ovary was enlarged to twice the usual size and contained a large red infarct. The parovarian cyst contained a thin bloody fluid. The tube was distended with blood.

Microscopically the cyst wall was semi-necrotic. The ovary showed a large hemorrhagic infarct. There was no trace of inflammation nor evidence of old scarring. The tube was congested and necrotic.

Case II. Mrs. M. C., No. 10309. Aged seventy-one. (Fig. 1.)

The patient had had one normal full term delivery fifty years ago and no other pregnancies. For years she had attacks of cholecystitis. There had been no attacks of dysmenorrhea. There had been nothing unusual during or about the time of the pregnancy and no abdominal operations. She was first seen in the University of Chicago Clinics in 1929, nineteen years after her menopause and at that time was found to have a hypertension with marked arteriosclerosis, pernicious anemia, and persistent constipation.

Death occurred from cerebral thrombosis. At autopsy the right adnexa were not found and there was no scarring at the site of amputation. The uterus was symmetrical but as there were several intramural myomata this was not very significant. There was not even a stump at the right uterine cornu. There was, however, a small calcified body, the size and shape of the normal left ovary, adherent to the parietal abdominal wall just lateral to the cecum.

On microscopic study no trace of the tube or round ligament was found in the broad ligament. The right cornu of the uterus, however, showed clearly a residue of the interstitial portion of the tube. The small body beside the cecum was sufficiently calcified peripherally to mask all the cortical structures. The general structure strongly suggested ovary, however, with tiny cysts toward the periphery and central ossification.

Case III. Mrs. G. O., No. 29045. Aged forty-seven.

This patient died from carcinoma of the stomach. Her previous illness had been typhoid and pleurisy. There had been six children and three miscarriages. She was still menstruating without abnormality or pain. There had been a

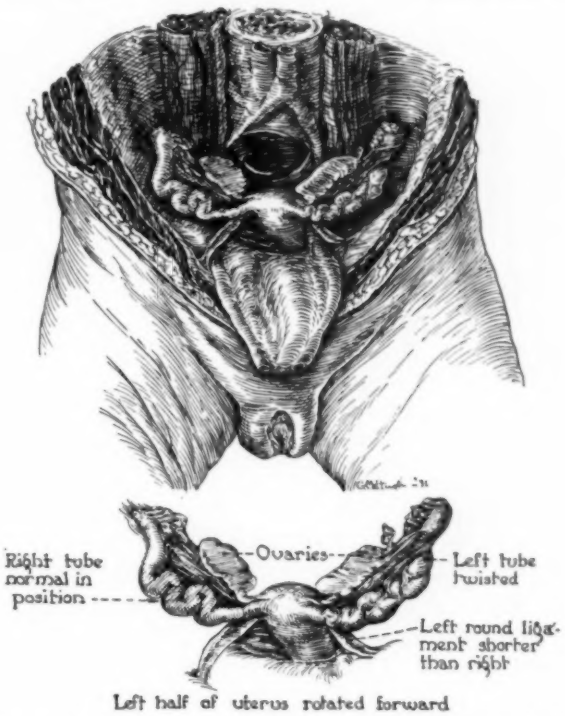
Right tube normal in position
Ovaries
Left tube twisted
Left round ligament shorter than right
Left half of uterus rotated forward

Fig. 2. Case VI. Pelvis of fetus 42 cm. long, showing spirals in left tube. Insert shows internal genitalia magnified.

pelvic repair and appendectomy fifteen years before. In 1923 there had been a six months period of pre-menstrual pain, which was bilateral and excessive, with marked dyspareunia.

The autopsy disclosed an anterior displacement of the left round ligament, with corresponding broadening of the superior part of the broad ligament. The left tube was slightly enlarged and hidden in a groove formed by the anterior rotation of the left ovary and its utero-ovarian ligament. The distal extremity of this tube was densely adherent to the sigmoid. The ovary was adherent to the broad ligament, and the adjacent tube. The ovary appeared normal, as did the right adnexa. The left tube was thickened and obstructed. The direction of the ovarian torsion was clockwise.

Microscopically there was no evidence of inflammation in the ovary but there was a well marked chronic salpingitis.

Case IV. Mrs. M. P., No. 27310. Aged forty-two.

This patient had had mumps in childhood. There had been one pregnancy, and an appen-

dectomy thirteen years before, but no history of trauma. For the last five years she had had tremendous premenstrual dysmenorrhea lasting one to two hours and always appearing about eight to nine hours before the flow began. This pain was not lateralized but was severe. There had been marked dyspareunia for the last three years. She came to the University of Chicago Clinics for metrorrhagia and menorrhagia. The uterus was found to be considerably enlarged. At operation the left tube was found dilated distally and the left tube and ovary twisted at least 180 degrees contra-clockwise. There were some adjacent adhesions. The right adnexa were negative.

On detailed examination of the specimen it was seen that torsion of the tube amounted to 140 degrees and that the ovary had undergone an additional 40 degrees or more of torsion in the same direction. The distal half of the tube was enlarged to three times normal size and was congested. There was ecchymosis in the portion of the mesosalpinx adjacent to the ovary. The uterus showed multiple fibromyomata.

Microscopically the ovary and tube showed edema but no marked congestion. There was some thickening of the tubal plicae but no evidence of infection.

Case v. Mrs. B. W., No. 32760. Aged eighty-one.

The patient had an uneventful menstrual history, with menopause at the age of forty-four. There had been eight pregnancies and normal deliveries. She came to the University of Chicago Clinics complaining of abdominal swelling of four months' duration with some gain in weight. This was very obviously due to a large ovarian cyst reaching almost to the xiphoid. On operation this was found to be connected with the left ovary and there was a complete contra-clockwise torsion of its pedicle. The other ovary was slightly cystic. On closer examination this was found to be a simple left monolocular cyst, free of adhesions and with no change in the adjacent tube. There were numerous coalescing fibromyomata in what remained of the left ovary.

Microscopically the tube was atrophic and the cyst wall showed nothing of interest.

Case vi. Baby Becker, 42 cm. long. (Fig. 2.)

This premature, well-developed fetus had a markedly anteflexed uterus rotated 30 degrees anteriorly on the left. The left round ligament was corresponding short and taut. The right tube was much convoluted. The left tube had a spiral near the cornu as well as farther out. Each was one complete turn and contra-clockwise.

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TREATMENT OF HERNIA

WITH SPECIAL REFERENCE TO THE INJECTION METHOD*

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THERE is little to be found relative to the treatment of herniae in ancient literature. In Cruden's Concordance[1] the word Hernia does not appear and in the Iliad and Odyssey[2] no mention of it is made. Just what the ancients did with patients suffering from this condition is not clear but given their ingenuity they certainly must have found some satisfactory treatment to prevent complications of this common condition. We must suppose that crude trusses were used from the very earliest times but accounts of this are meager. There are obscure references to the surgical treatment of inguinal hernia in early medical literature but definite attempts at operative treatment date back to Guy de Chauliac (1300–1370), while the attempt to cure ruptures by injecting irritating solutions in the neighborhood of the sac was not practiced until Velpeau in 1835. The technique was improved by Pancoast in this country in 1844 and in 1877 Schwalbe in Germany advocated injection of alcohol for the same purpose. Heaton (1877), Janney (1880), Warren (1881), Lannelongue (1901), and Manly (1893) made further contributions. At that time the standardization of the operative treatment of ruptures based on the transplantation of the cord as practiced by Bassini and improved aseptic technique became so satisfactory that the injection treatment was all but discarded and in modern textbooks the method is not even mentioned.

As a result of the work of Pina Mestre in Spain and Mayer in this country and others, interest in this method of treatment is being revived and gratifying results are being reported in a large number of cases.

The injection treatment of hernia aims to supplement rather than displace the operative treatment. The injection method is strictly limited to reducible herniae and it is absolutely contraindicated in sacs containing parts of abdominal viscera.

The aim of the injection treatment is to provoke an inflammatory mass in the subcutaneous tissues near the opening in the abdominal wall that will close the aperture very much as a cork stops a bottle. The mechanics of the procedure are not essentially different from that of a truss but in the injection treatment the pad is made up of the patient's own tissues and held in place by the skin and fascia of the patient.

There exists a great deal of confusion in discussions of this subject. For instance a consultant to the Council on Pharmacy and Chemistry[3] writes that it is not conceivable that it is good judgment to inject irritating substance blindly around a sac which frequently contains part of the abdominal viscera. This objection is disposed of by limiting the treatment to reducible herniae. He further states that this treatment is dangerous. Pina Mestre reports 8000 cases and Mayer 3000 over a period of thirty years without any serious accident. Serious complications have been reported after injecting strong alcohol[4] but this liquid is no longer used.

TYPES OF HERNIAE TREATED BY INJECTION

Inguinal, both direct and indirect, femoral and ventral hernia are treated or recurrences of these after operations. The principle of the treatment is the same in all these forms. The contents of the sac are

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first reduced and the opening in the abdominal wall is located and the injection is made near the neck of the sac, the forefinger acting as a guide and then a truss is applied. After two or three injections the hernial opening is closed by fibroplastic tissue and the truss is used only as a support until the scar becomes sufficiently firm.

SOLUTIONS USED

There are a number of solutions used. As a rule each observer has his own favorite formula; these are mostly secret and sometimes they are sold for a considerable price. There are three basic solutions and most others are variations of these. Alcohol was introduced by Schwalbe in 1876.[5] Mayer's solution has the following composition:

Zinc sulphate	4.0
Phenol	24.0
Glycerine	15
F. E. pinus canadensis (dark)	18
Water	60

Another favorite formula is that of Pina Mestre, called hernial.[3] The composition of this is given by Jameson[6] as follows:

Catechu	15.0
Monesia	14.0
Krameria	14.0
Rosa canina	15.0
Caccinium myrtilis	17
Alcohol (98 per cent)	25

This formula is indefinite and the preparation in ampoules must be obtained from the manufacturers in Barcelona. Mayer's solution has advantages but is painful to use; some say that it is not but any physician can readily clear up this point by injecting 2 to 3 c.c. of Mayer's solution in his own groin. Another objection is that the zinc salt is rapidly ionized and the effect is of short duration and necessitates frequent treatments. The tannic acid molecule which is the active ingredient of the Pina Mestre solution is much larger and disintegrates more slowly and the effect is maintained over a longer period of time, about a week.

The exact formula of the Pina Mestre solution is not available but by a little experimentation we have succeeded in making a preparation that has essentially the same effect and in some respects we think is superior to it. The composition is as follows:

Tannic acid	1.0
Ext. hammamelis U.S.P.	50.0
1/10 of 1 per cent butyn sol. in water	50.0
Metaphen (1:500)	1.0

This solution must be freshly prepared as solutions of tannic acid do not keep although the effects of the colored solution are the same as that of the fresh clear solution. In the technique of Pina Mestre as given by Jameson novocaine is injected first and then the irritating solution introduced, necessitating two separate injections. By combining the tannic acid and local anesthetic in one solution only one injection is necessary, thereby simplifying the technique. If care is taken to inject the solution slowly there is no pain whatever. Two or three hours after the treatment when the anesthesia wears off a sense of soreness is experienced and a tender mass appears at the site of injection. The size of the mass and the soreness are proportional to the quantity of the fluid injected and both reach their height about twelve hours after the treatment. It takes about a week for the mass and tenderness to completely disappear.

TECHNIQUE

To successfully treat a hernia by means of injections requires as much knowledge as to operate. Once it is decided to carry out this treatment the patient should be fitted with a truss, as a rule it is not wise to begin the treatment at once. A truss produces a certain amount of irritation at first and it is well to allow the patient to become thoroughly accustomed to wearing an apparatus before beginning treatment. Before the injection is made the patient is examined carefully in the recumbent position and the hernia reduced. With the index finger in the hernial opening for a guide 2 to 3 c.c. of the solution are injected with an ordinary hypodermic needle

near the opening in the abdominal wall. Care must be taken not to inject the cord. Once the injection is completed the truss is applied and the patient allowed to go about his business. If there is more soreness than usual a hot water bag usually gives relief or a mild sedative may be given. As a rule weekly injections are sufficient.

The number of injections necessary will vary with the solution used and specially with the skill of the operator. Mayer states that he gives 15 to 30 injections. With the Pina Mestre solution it usually requires less than this to effect closure of the hernial opening.

COMPARISON OF RESULTS FROM OPERATION AND INJECTION

The enthusiasts of this method certainly exaggerate the advantages and minimize the results of operation. They compare the results of an expert in the injection treatment with that of an ordinary operator. This is manifestly unfair. Our experience which includes familiarity with both methods has convinced us that while it is certainly possible to cure a hernia by injections, operation is to be preferred as a routine measure. The injection treatment has merits, however, and it would be wrong to ignore the advantages of this method. Before undertaking this form of treatment one must be sure of the indication. The small danger of operative treatment and the likelihood of recurrence are more than offset by the number of treatments and the time necessary to effect a cure by injections. Our best results with injections have been with recurrent herniae. If the sac is detected when small the weakness in the abdominal wall may be reinforced with a minimum of inconvenience to the patient and the surgeon can be spared the humiliation which accompanies surgical failure.

An unusually satisfactory result we have obtained with the injection treatment was that of a ventral hernia following a hysterectomy for fibroids in an obese patient. When we saw this patient two unsuccessful attempts had been made to repair the abdominal wall. We made a wide excision of the sac and surrounding scar and repaired the edges carefully but shortly after it was evident that as a result of weakness of the fascia recurrence was taking place. By means of injections the abdominal wall was reinforced and recurrence did not occur.

It is unfortunate that this treatment has not received the consideration that it deserves; it is either ignored or condemned by persons who have little experience with it or offered as a complete substitute for operation in the treatment of hernia. The truth lies somewhere between these extremes.

Any surgeon who is called upon from time to time to treat recurrences of other surgeons or possibly some of his own will find it well worth his while to familiarize himself with this method of cure and then there are special instances when for some reason or other operation is contraindicated. If the limitations of this treatment are kept clearly in mind and an exact technique carried out, gratifying results may be expected from the injection treatment of reducible herniae.

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[[For remainder of References see p. 514.]

AN AID IN THE DIFFERENTIAL DIAGNOSIS OF THE ACUTE SURGICAL ABDOMEN FROM INTERCOSTAL OR PARIETAL NEURALGIAS*

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THE diagnosis of acute appendicitis, perforated peptic ulcer, acute pancreatic necrosis, acute intestinal obstruction, acute cholecystitis with or without stone, and the diagnosis of the many other acute abdominal lesions has become fairly well standardized; yet every once in a while we advise or perform immediate laparotomy for some acute suspected abdominal catastrophe and are chagrined after long and careful search, evisceration and much trauma, that no surgical lesion can be found to account for the severe abdominal pain, tenderness and rigidity. An error has been made in diagnosis and surgical judgment which cannot justifiably be charged against the surgeon because of lack of an accurate method of differentiating the so-called intercostal parietal neuralgias from the acute surgical abdomen which they so perfectly mimic. As a result very sick patients are frequently subjected to abdominal exploration when such procedures are distinctly contraindicated.

To Dr. J. B. Carnett,[1] Professor of Surgery, Graduate School of Medicine, University of Pennsylvania, credit is due for his recent revival of interest and the focusing of attention of medical men on the importance of the neuralgias of the abdominal wall, and the facility with which they simulate a great variety of intra-abdominal affections.

The so-called non-surgical abdomen or intercostal or parietal neuralgia may be due to a great variety of causes and is a symptom-complex rather than a disease per se. Included in this group are the following: acute pleurisy, basilar pneumonia, herpes zoster, especially before the appearance of skin eruptions, fracture of the rib or spine, injury to the chest or abdominal wall, tumors of the spinal cord, meningitis, early tetanus, injections of antitoxin, sprain of a vertebral joint, spinal curvatures, arthritis of spinal vertebrae, bone spurs of the spine, Pott's disease of the spine, cancer of the spine, pulmonary tuberculosis, angina pectoris, diabetes, lead, alcohol and arsenic poisoning, gastric crises, anemias, and blood dyscrasias.

In order to detect parietal tenderness and to exclude underlying visceral tenderness, Carnett devised a test consisting in having the patient force the diaphragm down and holding the abdominal muscles tense to protect the abdominal viscera from palpating pressure. Any tenderness elicited during this maneuver he interpreted as parietal. But he also states that parietal tenderness occurs in the three layers of the abdominal wall which include the skin and its underlying fat, the muscles and their aponeuroses and the last layer, the parietal peritoneum and transversalis fascia. This test, as Dr. Carnett admits, is inadequate and does not accurately differentiate the combined tenderness of all three parietal layers of the abdominal wall from the tenderness due to pressure on an intra-abdominal diseased, traumatized or inflamed viscus.

The writer has been observing the phenomenon hereinafter described in all the acute surgical abdomens which have been operated upon under spinal anesthesia during the last two years which have come under his personal observation during that

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period. A recent case of a patient having a perforated peptic ulcer operated upon under spinal anesthesia will serve to illustrate the factors involved. It was fortunate that in this particular case there was a fifteen-minute interval to effect complete surgical anesthesia. This interval between the time of injection of the anesthetic agent into the subarachnoid space and the completion of surgical anesthesia is named for the purpose of this study the diagnostic interval.

CASE REPORT

Mr. L., aged fifty-five years, white, city fireman, chronic alcoholic, was awakened suddenly from his sleep at 2.00 A.M. April 13, 1931, with severe, excruciating pain in the upper half of the abdomen. Ordinary house remedies (sodium bicarbonate and hot water bag) gave no relief. At 4.00 A.M. the family physician was called and sent the patient to the hospital. He was seen by the writer at 5.00 A.M. that day. Examination revealed the classical symptoms and signs of perforated peptic ulcer, viz. boardlike rigidity of the entire abdominal wall, marked skin hyperesthesia, excruciating pain and tenderness. Operation under spinal anesthesia, 150 mg. of novocaine, third lumbar space, patient in Trendelenburg position. Numbness and tingling in both legs in two minutes. Complete motor paralysis of lower limbs in five minutes. Skin anesthesia immediately above suprapubic line at five minutes (pinching with mouse-tooth forceps). Pressure with stick sponge on lower half of abdominal wall caused excruciating pain. Skin anesthesia complete up to level of umbilicus at eight minutes. Deep pressure on abdominal wall below level of umbilicus still caused severe pain. One-inch skin incision, right rectus muscle, hurriedly carried through into peritoneum below level of umbilicus, each layer being lifted up towards the ceiling as it was cut, thus avoiding pressure on the abdominal contents. The 1 in. incision was complete between the eighth and tenth minute and caused no pain, whereas sponge-stick pressure below level of umbilicus anywhere on the abdominal wall still caused excruciating pain. Skin anesthesia beginning to creep up above level of umbilicus and was complete to ensiform and nipple line in fifteen minutes, although pressure between the tenth and fifteenth minute on abdominal wall above level of umbilicus caused excruciating pain, whereas extension of skin incision upward into this area with similar technique as used before, during the tenth and fifteenth minute interval, caused no evidence of pain.

Patbology found: Perforated duodenal ulcer with free fluid and gastric contents in abdominal cavity.

Procedure: Double purse-string suture with omental reinforcement.

Patient made an uneventful recovery.

What happened here, as well as in many other similar cases, can best be interpreted on an understanding of the relationship of the anatomy and physiology of the sympathetic nervous system to the spinal cord.

The entire nerve supply of the lateral and anterior abdominal wall is derived from the seven lower intercostal and first lumbar nerves. These nerves are mixed and contain motor and sensory fibers. It is a peculiar fact that the head, limbs and body walls contain no sympathetic sensory fibers. The visceral peritoneum and intra-abdominal viscera are supplied by the vagus and the sympathetic nerves derived from the bilateral thoracico-lumbar ganglionated sympathetic chain on either side of the vertebral column regulating in a beautifully counterbalanced physiologically antagonistic system by reciprocal innervation the vasomotor action of blood vessels, the secretion of glands, the contraction of involuntary muscles in the filling and emptying of the abdominal viscera.

Ried and DeWitt[2] have pointed out:

> The impulses conveyed by the visceral sensory fibers normally do not enter consciousness, but when intensified by visceral disease or malfunction may give rise to painful sensations which are not accurately localized and are referred to a cutaneous area supplied by sensory fibers from the same spinal segment.

It is common knowledge that under local anesthesia of the abdominal wall the stomach or intestine or other viscera may be cut without pain, and yet when these same viscera are undergoing pathological

changes of the acute variety or abnormal function, due to a block in the outlet of a hollow viscus, excruciating pain is experienced, localized not only in the viscus which is the site of its origin, but almost always in a somatic area which is supplied by nerves connected with the same segments of the central system as those which supply the viscus in question. Pain which is localized in an area other than that which is the site of its origin is known as referred pain. The anterior roots of the thoracic and upper two lumbar segments of the spinal cord send their fibers to ganglionated cords. The efferent medullated or preganglionated or white rami communicantes fibers pass to the ganglia in the sympathetic chain or to the ganglia at the bifurcation of blood vessels or in distant ganglia situated near the structure supplied. Originally, each ganglionated cord contained as many ganglia as there are spinal nerve roots, but the number has been somewhat reduced by the amalgamation of the adjacent ganglia. Thus in the cervical region the original eight pairs are represented by three pairs, namely, the superior, middle and inferior cervical ganglia. In the thoracic region the first, second, third or fourth ganglia on each side may be condensed to form a large stellate ganglion. From these three systems of ganglia non-medullated post-ganglionated fibers proceed to their destination. Those that pass from the proximal collateral ganglia enter the spinal nerves, the latter then being known as a made-up nerve.

The afferent visceral sensory fibers pass from the viscera into the sympathetic chain and proceed without interruption via the white rami into the mixed nerve trunks and thence to their cells of origin in the posterior spinal cord root ganglion and then the central axons pass by way of the posterior roots into the posterior horns, establishing contact with the elements of the cerebrospinal central nervous system; or having passed into the sympathetic chain, proceed upward in the ganglionated cord through ganglia at higher levels, and without interruption pass similarly via the white rami into mixed nerve trunks at these higher levels.

The contacts made by these afferent sympathetic fibers occur in three ways:[3] 1. With the primary efferent connector neurons in the intermediolateral columns, by means of which gastric and intestinal visceral reflexes and vasomotor reflexes are brought about. 2. With voluntary neurons in the anterior horn, by means of which visceral motor reflexes are brought about, as, for example, contraction of the abdominal muscles in cases of gastric irritation. 3. With the sensory system of the voluntary nervous systems: with the sensory cells in that segment of the spinal cord in which they have entered. Thus it is that sensory impulses arising from a viscus give rise to cutaneous pain or tenderness which is referred to the area of distribution of the posterior root belonging to that segment: this is known as referred pain.

In the light of this knowledge the interpretation of the significance of the so-called diagnostic interval can readily be understood. After low spinal anesthesia when skin anesthesia appears one can definitely say that there is underlying parietal anesthesia involving all layers of the abdominal wall, because the spinal or somatic nerves have been blocked at the level tested by pinching the skin. The sympathetic ganglionated cord is not directly affected by spinal anesthesia, but indirectly, and then only from below upward as the ascending cord paralysis blocks the afferent sympathetic pain impulses traveling to the spinal cord via the white rami communicantes. Sensory painful sympathetic visceral afferent impulses are allowed to ascend along the ganglionated chain to higher unblocked or as yet unanesthetized segments of the spinal cord; but soon the surgical or diagnostic interval is gone and the ascending spinal cord anesthesia has reached a high enough level to block all possible inroads of painful visceral impulses. The length of the surgical or

diagnostic interval will, therefore, vary indirectly as the rate of ascending diffusion of the injected anesthetic agent. The rate of such diffusion depends on certain accepted factors, viz., height of level of injection, dosage of drug used, nature of anesthetizing agent, volume and character of solvent, use of expanding procedure, force of injection, position of patient.

Recently a quinoline derivative, in small doses, 5 to 10 mg., has come into favor. The surgical or diagnostic interval with its use varies from twenty to thirty minutes and it is, therefore, especially adapted as an agent in the aid in the differential diagnosis of the acute surgical abdomen from the intercostal neuralgias. The test should be applied quickly during the surgical or diagnostic interval by two maneuvers: skin pinching with mouse-tooth forceps, beginning over the suprapubic region and extending upward, and pressure with sponge stick over the anesthetized skin area as soon as the latter is elicited. A positive test, if accurately and intelligently applied, is pathognomonic of an acute surgical abdomen. There can be no doubt then that immediate operation is imperative. A positive test is most frequently found in acute surgical lesions of the upper half of the abdomen. By a positive test is meant visceral pain elicited by sponge-stick pressure on an overlying anesthetized skin area.

It is reasonable to assume that the surgical or diagnostic interval will be very much shorter in acute surgical lesions in the lower half of the abdomen, or even absent or negligible in acute pelvic lesions, although the case has often been positive in early severe lesions of the appendix. The overlying skin anesthesia may appear simultaneously with the corresponding underlying visceral anesthesia. A negative text, therefore, in the lower half of the abdomen is not to be interpreted as an absence of a surgical lesion.

Fortunately, the intercostal neuralgias mimic most often lesions in the upper half of the abdomen.

Assuming a case of severe tenderness, pain and rigidity of the entire abdominal wall due to an early lower pneumonia or pleurisy will occur. Clinical findings indicate a possible acute perforated peptic ulcer and operation is advised. Low spinal anesthesia is advised. Skin anesthesia below umbilicus is absolute and complete in two minutes. Skin anesthesia is slowly ascending. Pressure with sponge-stick over anesthetized skin, as soon as such anesthesia appears, causes no pain, especially in the upper one-half of the abdomen, whereas previous to the administration of spinal anesthesia pinching of the skin elicited extreme hyperesthesia and pressure by palpation above the umbilicus elicited excruciating pain. This would indicate a typical negative test and point to the absence of an acute intra-abdominal lesion. Such a case is better left alone, or if the patient is operated upon the abdomen should be opened through a small incision and if no immediate evidence of pathology is found, such as free fluid or peritonitis, the abdomen should be closed without further exploration.

Therefore a negative test indicates no visceral pain elicited by sponge-stick pressure on an overlying anesthetized skin area as elicited by skin pinching.

Such a test in the upper one-half of the abdomen will help to rule out an acute surgical lesion. A negative test in the lower one-half of the abdomen is not as yet accurately defined since the diagnostic interval here is often of too short a duration.

CONCLUSIONS

1. Intercostal or parietal neuralgias are common and often mimic the acute surgical abdomen.

2. Heretofore experienced clinical judgment was the only means of differentiating the two conditions and then not always correctly.

3. Low subarachnoid block causes a relative separation or dissociation of the spinal cord and the ganglionated sympathetic cord for a varying interval. This

surgical or diagnostic interval is particularly noticeable in surgical lesions of the upper half of the abdomen.

4. Parietal anesthesia and visceral anesthesia do not appear simultaneously: parietal anesthesia appears before visceral anesthesia and they both appear from below upwards.

5. There is therefore an interval which allows time to determine whether the pain is parietal or visceral.

6. The rate of ascension of spinal anesthesia depends upon the height of injection of the anesthetizing agent, force of injection, amount of spinal fluid withdrawn and the amount of fluid injected, the physical and chemical nature of the injected agent and the position of the patient before and after injection.

7. The use of spinal anesthesia as an aid in the differential diagnosis of the acute surgical abdomen should be so used as to allow of slow ascension of the anesthesia along the spinal cord.

8. This study has also[4] conclusively demonstrated that so-called visceral or abdominal pain has three components, namely, (a) pure visceral pain felt inaccurately in the viscus affected; (b) referred pain to some portion of the parieties especially its cutaneous constituent; (c) pain caused by involvement of the parietal peritoneum.

9. Recently the use of a quinoline derivative as an anesthetic agent has allowed of a longer diagnostic or surgical interval.

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[For remainder of references see author's reprints.]

*Continued from p. 465.

A CASE OF UNUSUAL SUBLINGUAL DERMOID*

MORRIS JOSEPH, M.D., F.A.C.S.

PASSAIC, N. J.

E. C. a girl, aged eleven, was referred to me by Dr. Philip Simon, on July 28, 1931, with a large tumor filling the oral cavity. The child had always been in good health except that since she was about two years old she had had a swelling under the tongue which became steadily larger until the child was unable to protrude the tongue, and both speech and swallowing were very much impaired. It was also noticed that the lower jaw began to protrude. At the time of the examination the child was only able to take fluids with difficulty, her breathing too was more or less obstructed. The father stated that nothing had been done about this growth because they were afraid of an operation and they "pitied the little thing."

A B C D

FIG. 1.

Physical examination showed a sparely nourished child with a moderate grade of anemia, quite intelligent, with an anxious expression. It was difficult to understand her speech. There was some puffing under the eyes and the lower jaw showed marked protrusion. The entire oral cavity was filled with a large soft rounded fluctuating mass. Her physical examination was otherwise negative.

On July 30, the tumor was excised under local anesthesia and was found to extend back to the base of the tongue and the pharynx.

Pathological Report: The tumor is cystic in nature, weight 97 gm., measuring 6.5 × 6 × 5.5 cm. The specimen is filled with fatty secretion. There are two slightly elevated plaques in the lining. Microscopic: Dermoid cyst.

The child made an uneventful recovery following the operation and was able to protrude her tongue from her mouth for the first time in years. She began to eat with a very ravenous appetite and has gained weight steadily since the operation.

FIG. 2.

The accompanying illustrations show the child immediately before and after the operation and also the exact size of the tumor.

DISCUSSION: This type of tumor was generally regarded as a ranula until the excellent review by Colp in 1925. As shown by him more careful microscopic examination places these tumors among the dermoids.

* Submitted for publication October 27, 1931.

DERMOID CYST OF THE TEMPORAL FOSSA*

JOE. E. HEARD, M.D., F.A.C.S., AND PAUL D. ABRAMSON, M.D.

SHREVEPORT, LA.

TUMORS of the temporal fossa are rare surgical specimens and are apparently reported even less frequently than they occur. We therefore feel that a report of a case of dermoid cyst of the temporal fossa is justified and should prove of some interest. A fairly comprehensive review of the literature reveals very little concerning tumors of this region. Bloodgood,[1] in an experience extending over twenty-three years, has seen but 7 cases in all: 5 of these were explored and a definite diagnosis made, while in 2 cases a positive diagnosis was not determined. The 5 cases in which an exploratory operation and biopsy were performed were classified as follows: one was a gumma, one a dermoid cyst, one a myxosarcoma metastatic from a brain tumor and two were Ewing's sarcoma of bone. From a review of these cases, Bloodgood naturally concludes a malignant condition to be the most frequent tumor seen in this region.

Learmonth and Kernohan[3] have recently reported 3 cases of epidermoid cyst of the brain. However, the case reported herein was definitely extradural, and while it must be realized that a histologically similar tumor may arise from intracranial cell inclusions, they do not simulate tumors of the temporal fossa, and usually arise near the midline.

The patient, who is the subject of this report, is a young white female, aged twenty years. She was admitted to the North Louisiana Sanitarium on July 13, 1931, being referred by Dr. S. C. Barrow. She complained of a right-sided exophthalmos and pain in and about the right eye, with slight diplopia, these symptoms being of approximately three weeks' duration. Analysis of the history revealed that she had noticed some slight swelling just above the right zygomatic arch for about one year, which though slightly noticeable, had been largely ignored, as it had otherwise been asymptomatic. Approximately three weeks prior to admission, however, there had been a rather sudden onset of intense pain in and about the right eye, with a sudden marked proptosis of this eye developing. Vision had been only slightly affected, a diplopia occurring apparently as a result of the two eyes being suddenly thrown out of line. Except for this diplopia, some pain (though it had subsided after the first acute attack) and exophthalmos, the patient had no particular symptoms. In retrospect, the patient recalled an injury to this region (right temporal), received when a child, the sharp edge of a saw tooth having struck her here. However, it had occasioned only immediate trouble, and had been forgotten until she was questioned closely.

Physical examination likewise revealed comparatively little definite information. The ophthalmological examination (Dr. L. W. Gorton) showed a definite, well-marked right-sided exophthalmos, non-pulsatile, and with a grossly normal bulb. The fundi were normal, as were the pupils and their reactivity. No contraction of the visual fields or other ocular phenomena were noted, excepting the diplopia and some photophobia.

A definite fullness was present in the right temporal region, evident above the zygomatic arch. This swelling was not pulsatile, and careful auscultation about the head revealed no murmurs or bruits. Careful examination of the rest of the body failed to reveal any abnormalities.

A spinal survey revealed normal-appearing fluid, under normal pressure, which was also cytologically, chemically and serologically normal.

Routine laboratory studies, including urinalysis, blood picture, blood chemistry and serology showed no deviation from the normal.

Roentgen examination (Dr. S. C. Barrow) of the head showed a well-marked erosion along the external border (posterior aspect) of the orbital ridge.

* From the Surgical Section, North Louisiana Clinic. Submitted for publication November 3, 1931.

In view of the swelling above the zygomatic arch and the erosion of the posterior aspect of the orbital ridge, it appeared quite obvious

Fig. 1. Skiagraph taken prior to operation. Arrow indicates where orbital ridge on right side has been eroded, as contrasted to normal left side.

that there was some type of enlargement occupying the temporal fossa. The non-pulsatile nature of the exophthalmos, the normal spinal pressure, the normal fundi, the normal visual fields all mitigated against the presence of primary intracranial or intra-orbital pathology.

The findings seemed best explicable on the basis of a slow growing lesion in the temporal fossa which had suddenly penetrated into the orbit, producing the exophthalmos and sudden, acute pain.

As to the nature of this temporal fossa pathology, there seemed three possibilities: (1) an infectious process, including a gumma; (2) a neoplasm, either benign or malignant; (3) an aneurysm. Despite the acuteness of the onset of the recent symptoms, the afebrile state, lack of local inflammatory signs, normal blood count and negative serology served to mitigate against the possibility of an infectious process.

The most probable diagnosis rested between an aneurysm or a neoplasm. In view of the history of trauma to this region, the possibility

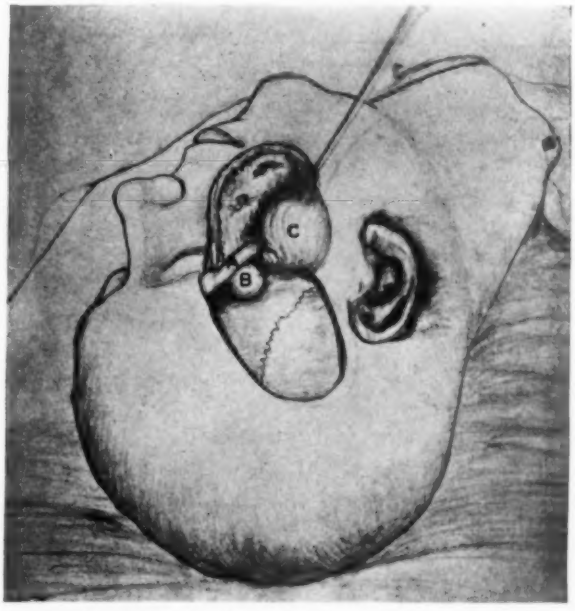

Fig. 2. Appearance of tumor as seen at operation. For sake of orientation drapes have been omitted. Our artist has failed to depict the degree of exophthalmos existing at operation. A, External orbital ridge, middle third of which was resected in order to remove sebaceous material in retrobulbar space. B, Main portion of cyst occupying temporal fossa resting against greater wing of sphenoid. C, Retracted temporal muscle, portion of which has been omitted in order to demonstrate tumor better.

of a traumatic aneurysm dating back to childhood, and which had caused a sudden retrobulbar hemorrhage, was considered. However, the absence of pulsation and bruit were against such a conclusion. There was nothing which could serve to rule out a diagnosis of a neoplasm, which had perhaps eroded a small vessel, and produced a retrobulbar hemorrhage.

However, it was felt that exploration was essential for a correct diagnosis. The preoperative diagnosis was aneurysm vs. neoplasm, nature unknown. On July 15, 1931, under ether anesthesia, an exploration of the temporal fossa was made (J. E. H.). The field was prepared with benzene, iodine and alcohol, draped, and a horse-shoe incision made, starting at the external border of the superciliary ridge, extending over the temporal region and ending about ¼ inch below the center of the zygomatic arch, the base of the flap being below. This flap of skin, fat and fascia was dissected and thrown downward and forward toward the

face, exposing the temporal muscle. About two-thirds of the temporal muscle was reflected backward, exposing the temporal fossa, in

FIG. 3. Patient about two weeks after operation. Scar is a little wide because of slight suppuration at skin margins. Notice that no exophthalmos is present.

which was a small, cyst-like mass, about half the size of a peanut, with two projections extending from it: one extending through an eroded opening in the greater wing of the sphenoid, one seeming to penetrate the infra-orbital fissure. The sac was freed up to its neck, which protruded through the opening in the sphenoid, about the size of a dime. A small trephine opening was made just above the eroded opening in the sphenoid and the intervening bone rongeured away, connecting the two openings. The prolongation from the cyst in the temporal fossa was found to be entirely extradural, and was removed from the middle cerebral fossa. The eroded bone was rongeured and curetted. A small ¼ cm. opening which had been accidentally made in the dura by the trephine was sutured with chromic 00. The sac, at this point, was opened and found to contain sebaceous-like material. The external rim of the orbit was then cut with a motor circular saw, a pyramidal-shaped piece of bone about 2.5 cm. each way being removed from the mid-portion, thus exposing the retrobulbar space. It was seen that the sac had not extended through the infraorbital fissure but had ruptured, spilling its contents into the retrobulbar space. Quite obviously, it was this sudden rupture and filling of this space that had produced the sudden exophthalmos and pain. After the periosteum had been freed from the inner surface of the orbit, the space was cleaned out well, and the bone wired back in place with silver-bronze wire. The cyst was entirely removed and the temporal muscle sutured back in place with a continuous chromic o suture. The fascia and subcutaneous fat were closed with the same suture material, skin closure being made with a plain o subcuticular suture. Postoperative diagnosis: dermoid cyst.

Postoperatively, the patient had a splendid recovery. Except for a rather marked peri-orbital edema and discoloration, and diplopia, which lasted but a few days, the patient had an uneventful convalescence, being discharged from the hospital on July 27, 1931.

The pathologist's report was as follows: "The specimen is a cyst-like membrane which apparently has been opened and its contents removed. It is roughly 4 × 6 cm. in dimensions and 1 mm. thick. The sac is lined with a glistening membrane, bluish in color, the outer surface being smooth, and grayish in color. Microscopic examination shows the cyst wall to be lined with stratified squamous epithelium, with no hair follicles or other skin appendages being evident. Small amount of striated muscle attached to outside of sac wall (temporal muscle?)."

The possibility of the sharp, cutting instrument having carried a remnant of skin into the temporal fossa, at the time of the childhood accident, and which had remained latent for a number of years, must be considered; but the absence of hair follicles makes this an unlikely possibility. The patient is alive and well now, three months after operation, with no symptoms.

SUMMARY AND CONCLUSIONS

1. An unusual case of dermoid cyst of the temporal fossa is presented, in which the tumor had eroded into the middle cerebral fossa through the greater wing of the sphenoid, and penetrated the retrobulbar space, producing unilateral exophthalmos.

2. The operative procedure by which this tumor was removed, is described.

3. A possible explanation is offered for the origin of this tumor by the penetration of the temporal fossa earlier in life, of a sharp instrument which may have implanted a piece of skin into this region.

[For References see p. 534.]

DESMOID TUMOR OF THE ABDOMINAL WALL*

DANIEL H. BESSESEN, M.D.

MINNEAPOLIS, MINN.

THE patient, a divorced woman of forty-one, occupied as laundress, complained of soreness and swelling in the region of an appendectomy scar.

There was nothing in the family or social histories at all leading. She had been married ten years and had divorced her husband one month prior to admission to our care. She had never been pregnant. She was engaged in work which was quite strenuous physically and this work had made the soreness in her right side more noticeable.

The appendectomy had been performed eleven years previously by a well-qualified surgeon, and in the fall of 1928, a mass appeared in the region of the scar. When she first noticed it, it was the size of an almond, but had now reached the size of a hen's egg (Fig. 1). There was also present some infection about the teeth and a slight enlargement of the thyroid gland.

Operation on March 27, 1929 consisted of cautery removal of the mass incising through the skin and fat with a knife to the aponeurosis of the external oblique. The tumor itself was buried in all the abdominal muscles and the excision left the appearance seen in Figure 2.

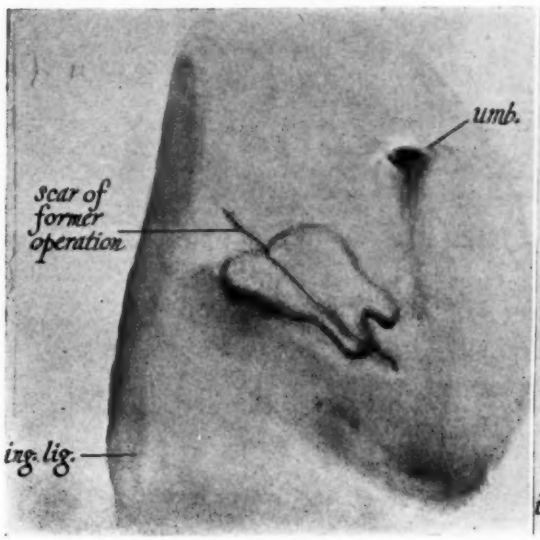

FIG. 1. Appearance of tumor.

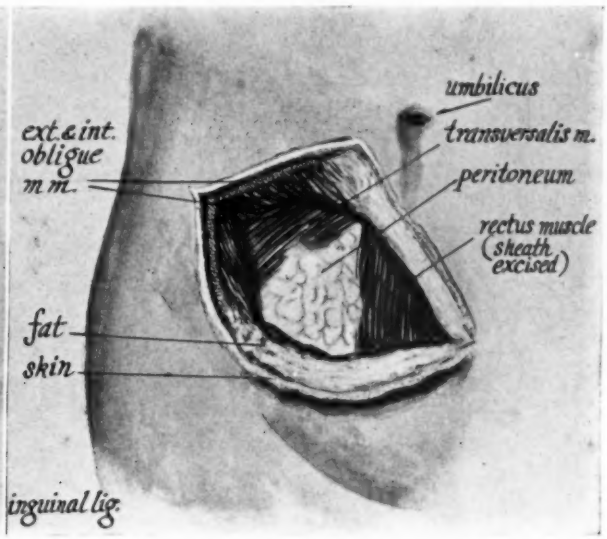

FIG. 2. After excision of desmoid.

The rectus muscle was drawn well to the side, and stitched by continuous mattress sutures as indicated (Fig. 3) to all the lateral layers of the abdominal musculature. A piece of fascia lata was removed from the right thigh, 4 by 5 inches, and stitched so as to overlie the sheath defect (Fig. 4) chromic No. 2 sutures being used. The fat and skin were closed by plain No. 1 and dermol respectively.

The following day, the patient complained of sore throat. Cultures contained diphtheria bacilli and she was sent from New Asbury Hospital to the contagious ward of the General Hospital, where 20,000 units of diphtheria antitoxin were administered.

The subsequent convalescence was uneventful. The patient was up on the seventeenth day and has returned to her usual labor.

Desmoid tumors of the abdominal wall are infrequent. Still less often are they recognizable before operation. They are usually hard, not clearly defined by capsule and tend to become sarcomatous. The usual site of these tumors is over the rectus muscles, and they are more common in women than men.

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The symptoms in this case might lead one to believe that the tumor had become malignant because of the rapid growth and type, with the reinforcement by transplant of fascia lata gave a very practical result, allowing the patient the same

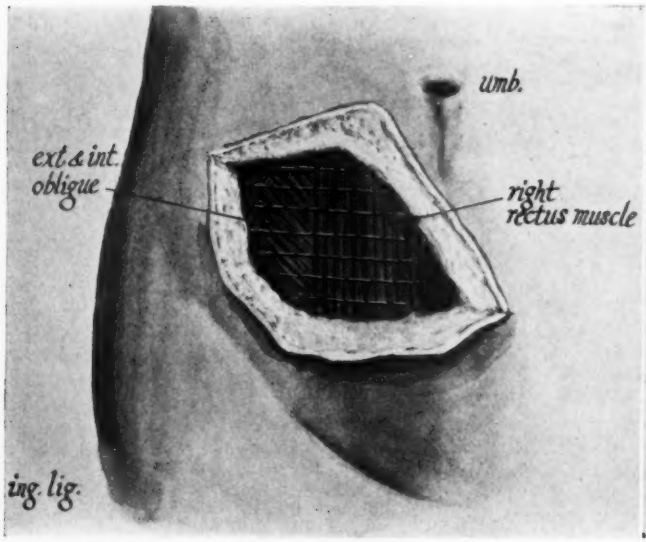

Fig. 3. Appearance of closure before fascial transplant.

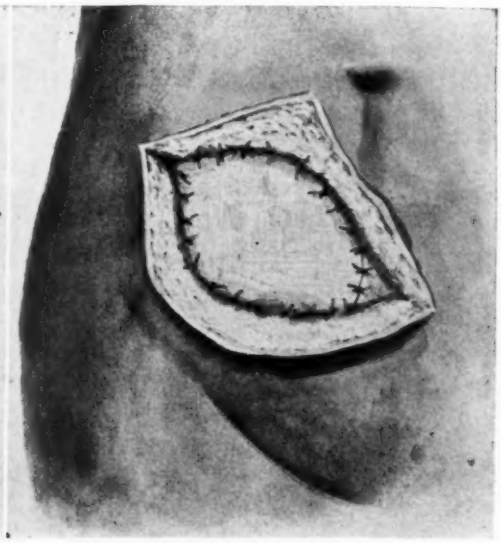

Fig. 4. Transplant of fascia lata.

pain attendant. However, the constant movement of the parts in which the tumor was buried may have produced both the growth and the tenderness. The incision was carried well around the growth, the cautery being depended on to make more remote a possible recurrence in case of malignancy.

Closing such a large gap in the abdominal wall has long been a problem. Here the use of a many-knotted suture of the mattress strength as prior to the operation.

Diphtheria is a fairly common malady, but is most unwelcome as a postoperative complication. It may be checked certainly if recognized early. This patient must have had the organisms present in the throat before her entry to the hospital. She was removed to the contagious hospital on the day the microscopic diagnosis was made and treated promptly.

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*Continued from p. 503.

THE RELATIONSHIP BETWEEN

HYDRONEPHROSIS AND ABERRANT RENAL VESSELS

REPORT OF AN UNUSUAL CASE OF BILATERAL HYDRONEPHROSIS ASSOCIATED WITH ABERRANT VESSELS*

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NEW YORK

MUCH has been written in the past two decades on the subject of hydronephrosis, and especially upon that phase of the condition dealing with its pathogenesis. The relationship of aberrant renal vessels to hydronephrosis, however, although frequently discussed, is still insufficiently understood and appreciated to warrant the condition being established as a definite and sufficiently frequently encountered cause for this pathological renal entity. The purpose of this paper is to place on record another case of bilateral hydronephrosis associated with aberrant vessels and to emphasize the importance of early recognition of this type of anomaly as a potent cause of complete destruction of renal parenchyma.

FIG. 1. Left pyeloureterogram showing ureter filled to level of fourth transverse process beyond which it cannot be visualized. Pelvis contains no dye. That portion of ureter which is outlined appears to be dilated.

FIG. 2. Retrograde right pyelogram showing sac-like dilatation of pelvis, absence of calyces and dilatation of ureter.

CASE REPORT

E. C., female, aged twenty-four, unmarried, was first seen April 6, 1931, complaining of pain in the left flank of a few weeks' duration. The pain was of a dull aching character and was accentuated by movement and by breath-

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ing. She had to void every hour during the day and twice at night. There was no history of chills, fever or dysuria. Her appetite was good, and bowels regular. There was no history of cough or night sweats.

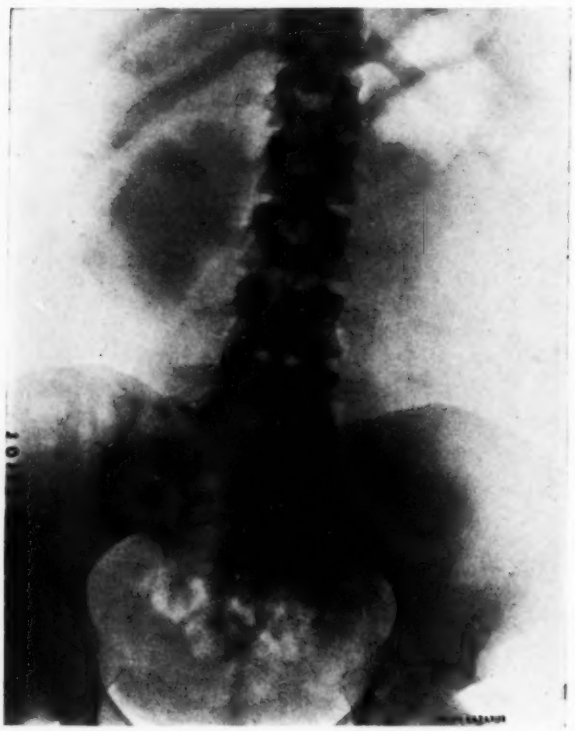

Fig. 3. Intravenous pyelogram (three hour film) showing hydronephrotic right kidney with absence of dye on left side.

At the age of eleven, she had an attack characterized by chills and fever, which was diagnosed and treated as malaria, although the symptoms persisted for one year, following which she felt perfectly well until five months ago when she noticed black spots in front of her eyes. Four months ago she was in bed with an attack of chills and fever lasting for five days.

Family history was essentially negative.

Cystoscopy revealed a turbid, foul smelling urine in the bladder. Save for a slight injection around the ureteral orifices, the bladder looked perfectly normal. The right kidney was easily catheterized, and the urine from that kidney which contained many pus cells with clumps, showed very poor phenolsulphonephthalein concentration. The left catheter encountered an impassable obstruction at 24 cm. from the bladder, so that no urine could be obtained from that kidney. The following day, indigo carmine was given intravenously, and after thirty minutes no return of the dye could be seen coming through the left ureteric orifice, while that from the right was of poor concentration. Specimens from the right kidney and bladder revealed a pure growth of B. coli communis on culture and were negative for the bacillus of tuberculosis.

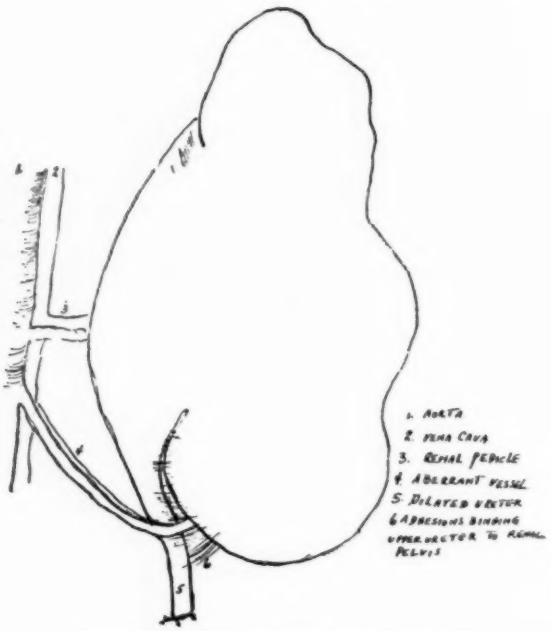

Fig. 4. Conditions found at operation.

Two hour phenosulphonephthalein examination showed less than 5 per cent for the first hour and 8 per cent for the second.

Roentgenological Examination: A film taken with opaque catheters in both kidneys showed the tip of the right catheter lying opposite the fourth transverse process. The left catheter was seen to make a loop in the region of the lower ureter and its tip was seen lying along the lower margin of the fourth lumbar vertebra. A shadow of a calculus could not be visualized along the course of either ureter.

A left retrograde pyelogram disclosed the medium reaching to the fifth lumbar vertebra. The ureter was dilated but there was no evidence of any of the pyelographic solution within the renal pelvis. The renal silhouette appeared enormously enlarged, reaching from the twelfth rib to about 1 in. above the crest of the ilium (Fig. 1).

The right pyelogram showed the pelvis converted into a large, ovoid sac measuring 11.5 cm. by 7 cm. The ureter appeared dilated (Fig. 2).

Intravenous pyelography revealed the fact that no dye was present in either renal pelvis after fifteen minutes, although the renal outlines were well demarcated and showed the left renal silhouette enormously enlarged, especially at its lower pole which was globular in outline and appeared to be separated from the upper part of the kidney by a groove or a line of demarcation giving the impression that it was cystic. The right kidney shadow was also markedly enlarged. A film taken one hour later still showed no dye in the left pelvis, bladder and ureters, although there was some mottling of the right renal shadow. Three hours after the injection of the dye another film was taken which again failed to show any trace of the dye in the left pelvis. The pelvis of the right kidney was filled, and simulated closely the condition found on the retrograde pyelogram (Fig. 3).

Fig. 5. Kidney, immediately after its removal.

Fig. 6. Kidney showing ureter stump and divided aberrant vessel. Adhesions between ureter and pelvis have been divided in preparation of specimen.

Blood Count: Hemoglobin 75 per cent. Erythrocytes 4,500,000; leucocytes 12,400. Segmented forms 64 per cent. Band forms 18 per cent. Small lymphocytes 14 per cent; mononuclear leucocytes 2 per cent and myelocytes 2 per cent.

Blood Chemistry: Urea nitrogen 31.2. Sugar 96 mg. per 100 c.c. of blood.

Physical examination revealed a fairly well-developed, alert and intelligent girl, twenty-four years of age, who did not appear acutely ill. The skin and conjunctivae appeared pale. A peculiar uriniferous scent was detectable from the skin and breath. The thyroid was

slightly enlarged. Blood pressure 120/80. Abdominal examination revealed two large palpable soft kidneys. There was no costovertebral tenderness. The rest of the examination was essentially negative.

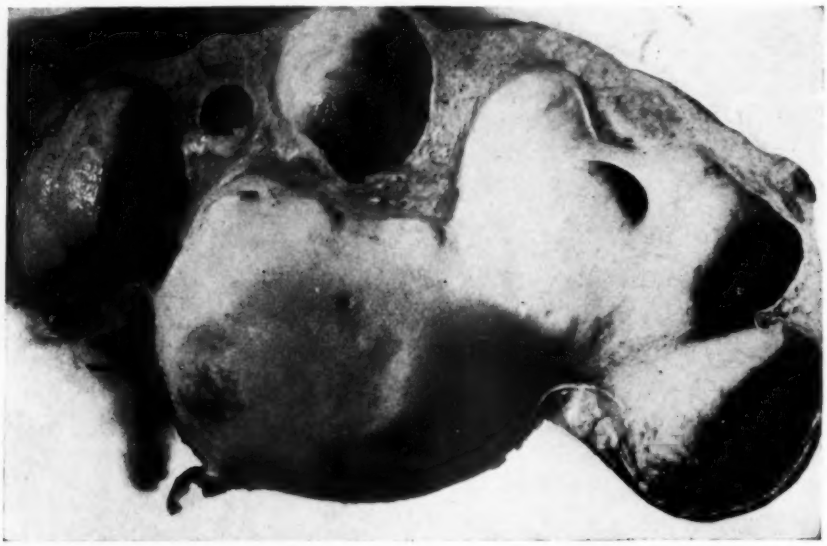

Fig. 7. Sagittal view of kidney showing nature of hydronephrotic changes.

From the history and findings in this case, a tentative diagnosis was made of bilateral infected congenitally hydronephrotic kidneys due either to strictures at the ureteropelvic junctures or to aberrant blood vessels. Exploratory operation upon the left completely obstructed kidney was advised.

Operation, April 13, 1931. Under spinal anesthesia the left kidney was exposed through an 8 in. Albarran incision. It was completely hydronephrotic and extended from the under surface of the diaphragm to the true pelvis. There was a considerable degree of perinephritis. Extending from the vena cava and aorta, two vessels were seen crossing the ureter and apparently compressing it. The upper few inches of ureter were intimately adherent to the under surface of the renal pelvis by dense adhesions. The entire renal cortex was attenuated to the thickness of writing-paper (Fig. 4). A typical nephrectomy was performed.

Postoperative Course: April 16, 1931. Blood urea 27.7; creatinine 3.2 mg. per 100 c.c. of blood.

April 20, 1931: Blood urea 25.9 mg. per 100 c.c. of blood.

Following a perfectly uneventful convalescence, the patient was discharged from the hospital on April 27 with the wound healed by primary union.

Pathological Report: Specimen consists of a kidney measuring 17 × 11 × 8 cm. On section, about 300 c.c. of thick yellowish fluid escaped from the kidney, which was completely hydronephrotic. The pelvis is markedly dilated with a number of small cysts scattered through the cortex.

Histological sections showed marked pus cell infiltration within the remains of the parenchyma with a few scattered foci of lymphocytes. Many glomeruli were completely replaced by collections of pus cells. There was no evidence of tuberculosis (Figs. 5–7).

The patient was again seen on August 1, 1931, stating that she felt well and strong. She voided eight to ten times during the day and once at night. She complained of no special symptoms. Blood pressure 138/80. Combined two hour phenolsulphonephthalein test was 15 per cent. Blood chemistry (August 3): urea nitrogen 22.9 mg. per 100 c.c. of blood and creatinine 1.85 mgm. per 100 c.c. of blood.

COMMENT

This is a case of a girl, twenty-four years of age, who thirteen years previously was treated as a case of malaria because of chills and fever lasting for about one year. Eleven years later, because of pain in the left loin, she returned for examination which revealed a completely obstructed

and enlarged left kidney, and a definitely hydronephrotic right kidney, the combined function of both being very low as determined by the phenolsulphonephthalein test, but in spite of which there was little retention of nitrogenous products within the blood. From the history and findings of a complete urological study a diagnosis was made of bilateral congenital infected hydronephrotic kidneys due either to obstruction at the ureteropelvic junctures or to aberrant vessels. Operation upon the left kidney revealed the obstruction to be apparently due to aberrant vessels. In view of the condition of the kidney which was completely destroyed, no alternative was left but to remove it, reasoning that since the kidney had been completely blocked, and since the patient had been carrying on a fairly normal existence, that in all probability she was living on the right kidney and that removal of the left kidney would not only not do any harm, but might enhance the function of the right kidney.

That this opinion was correct was more than amply borne out by the subsequent course of the case. Furthermore, because we found the cause of the obstruction to be due to aberrant vessels on the left side, and an hydronephrotic kidney on the right, it is not stretching the imagination too much to assume that a similar cause might be responsible for the right hydronephrosis. As to the best course to follow regarding treatment for the right kidney, it is difficult to state with absolute certainty. Should the function of the kidney improve under observation, it might be best to depend upon palliative measures such as the wearing of a properly fitted support to raise the kidney, and a low protein diet. Should the condition fail to improve, a conservative surgical procedure might be indicated to relieve the obstruction.

INCIDENCE

The incidence of aberrant vessels is much higher than is generally believed. Eisendrath and Strauss[1] examined 1200 kidneys and found aberrant arteries present in 21 per cent of them. Anomalies of the renal vein are more frequently encountered than those of the arteries, but are of little clinical importance. Young[2] quotes Brewer as having found in 85 bodies more than one artery on one side in a study of 151 cadavers, an incidence of 50 per cent. Lowsley, Kingery and Clarke[3] found 62 renal vessel anomalies in a collection of 4215 autopsies, or 1.47 per cent. Yet, it is of great significance to note that from a study of 4903 post mortems upon children, that Bugbee and Wollstein[4] found no case of aberrant vessels although there was a great preponderance of cases of hydronephrosis amongst them. A similar experience has been reported by Bigler[5] who found 20 cases of anomalies within the genitourinary tract in 153 autopsies on children, but not one case of aberrant vessels. It would appear therefore from a statistical review of the literature that aberrant renal vessels are not uncommon, and that in about 2 per cent of all children, some type of ureteral obstruction is encountered. Yet these statistics fail to show any relationship between the two conditions since no child coming to autopsy with hydronephrotic kidneys has shown the presence of aberrant vessels.

AGE

Symptoms due to hydronephrosis caused by aberrant renal vessels appear most frequently in early adult life, although Campbell and Lyttle[6] report 7 cases of patients operated on out of which 4 showed symptoms since childhood. Hutchinson[7] reports 22 cases, the youngest patient being fifteen and the oldest thirty-eight years of age. The age limit in Stevens'[8] series of 13 cases was between twenty-three and sixty years.

PATHOGENESIS

The finding of an aberrant vessel in conjunction with an hydronephrosis does not constitute conclusive evidence that

the aberrant vessel caused the hydronephrosis. Yet, aberrant vessels do cause hydronephrosis.

Various theories have been advanced to explain the exact manner in which hydronephrotic changes are produced. Quimby[9] for example maintains that the mere contact of the pulsating vessel against the ureter wall suffices to interfere with its normal peristalsis, and thereby with the proper emptying of the kidney. He does not attribute the hydronephrosis to a direct mechanical occlusion of the ureter by the vessel.

Another theory advanced is that a real mechanical obstruction is produced in the ureter at the site of the aberrant vessel by pressure and by adhesions resulting from repeated infections (periureteritis) which eventually lead to a fixation of the ureter at that point.

The most plausible view is the one which explains the pathogenesis on the ground that the vessel crossing the ureter acts as an actual mechanical obstruction when associated with a movable kidney, or an infected one, the infection leading to increase in the size and weight of the organ, and thereby causing it to sag from its normal position and to produce a suspension of the pelvis or upper ureter over the vessel.

There is still another, although smaller, group of observers who maintain that aberrant vessels are in no way responsible for the presenting hydronephrosis (Spitzer,[10] Hahn[11]).

SYMPTOMATOLOGY

Symptoms associated with aberrant vessels are identical with those due to hydronephrosis, such as intermittent attacks of renal colic, repeated onsets of pyelitis, and a palpably enlarged kidney. Cystoscopically there is an absence of findings suggestive of calculus. Obstruction may or may not be encountered by the ureteral catheter. Pyelography shows definite evidence of hydronephrosis with or without hydro-ureter, angulation or narrowing at the site of the lesion, and at times a break in the continuity of the ureterogram at the line of crossing of the aberrant vessel.

TREATMENT

The treatment of this condition is primarily surgical. Conservative surgical measures usually suffice to relieve the symptoms. Nephrectomy is reserved for kidneys which are hopelessly affected.

Various procedures have been advocated for relief of the existing obstruction. Division of the aberrant vessel, if not too large, has been successfully performed in a number of cases. Should the size of the vessel preclude this procedure because of the danger of compromising too much renal parenchyma, a better course to follow is to divide the ureter and to reunite it in such a way that any contact with the aberrant vessel would be obviated. Ureterolysis and nephropexy are useful accessories to the treatment when indicated.

The outstanding feature of the treatment is prophylaxis; that is, in the cases of obstruction at or near the ureteropelvic juncture where non-operative treatment fails to give relief in a reasonable period, exploratory operation is indicated for the purpose of instituting appropriate measures for the correction of the deformity causing the obstruction before any marked hydronephrotic changes have occurred.

SUMMARY AND CONCLUSIONS

1. Aberrant vessels, while not uncommon as an anomaly of the renal circulation are less commonly responsible for hydronephrotic changes of the kidney.

2. Various theories are outlined attempting to explain the manner in which such vessels produce their deleterious effect upon the kidney, their outstanding feature being some interference with the emptying of the kidney either directly or indirectly as a result of the proximity of the aberrant vessel.

3. The symptomatology associated with this anomaly is that due to the concomitant hydronephrosis.

4. The outstanding feature in the treatment of this condition is the early recognition of this anomaly which is made possible only by subjecting all cases of obstruction at or near the ureteropelvic juncture that have not responded to conservative non-operative measures to exploratory operation.

5. Division of small vessels or division of the ureter and its subsequent repair in such a way that it is free of the offending vessel are measures frequently employed in conjunction with nephropexy and ureterolysis. Nephrectomy is employed when the kidney is damaged beyond the possibility of repair.

6. A case is here reported of bilateral hydronephrosis associated with aberrant vessels which necessitated nephrectomy of the worst kidney in order to spare its less affected mate.

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[References continued on p. 525.]

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TWO CASES OF LIPOMA*

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BECAUSE of the unusual size and location of the lipomata in the 2 cases described below their record is considered of value.

CASE 1. A. N. male, aged thirty-two, white, was admitted to the Prospect Heights Hospital May 2, 1930 with the history of a swelling of the right thigh of twenty years' duration. Three months ago the swelling began increasing in size and causing some pain. Recent trauma could not be established in the history. During the years of the World War the thigh had been subjected to constant irritation in the saddle.

Physical examination was entirely negative, except for the local findings of the right thigh. This was 7 cm. larger in circumference than the left at a point midway between the greater trochanter and the upper border of the patella. This enlargement was due to a tumor occupying the entire antero-medial aspect of the thigh. With the muscles of the thigh relaxed the tumor was soft, not movable on the underlying tissue, the size and shape of a small watermelon, giving an indefinite sense of fluctuation. This pseudo-fluctuation disappeared, however, when the muscles of the thigh were tensed. No lobules could be made out. The palpation was quite painless. T.P.R. as well as all laboratory findings were within normal limits.

Preoperative Diagnosis: Deep-seated intermuscular lipoma of the right thigh.

Operation: Under gas-oxygen anesthesia an incision 20 cm. long was made over the most prominent part of the swelling in the long axis of the thigh. The fascia was incised to the same extent exposing the vastus externus. The fibers of this muscle were separated in its upper and lower portions and through these windows the fatty growth was enucleated. The lipoma extended from Scarpa's triangle to the point of insertion of the flexors of the thigh on the medial aspect of the knee. It lay immediately upon the femur and was intimately connected with the periosteum by dense fibrotic bands. The capsule of the lipoma was well developed and very vascular. At the lower pole of the tumor the vessels formed a pronounced pedicle which was ligated. The dead space was obliterated by plicating the vastus muscle which measured about twice its normal length. A Penrose drain was placed into the lower angle of the wound, reaching into the region of the vascular pedicle. The fascia and skin were closed in layers and the patient was urged to use the limb in bed.

The pathologist reported the tumor as a simple lipoma with increased fibrous interstitial tissue and markedly rich vascularity. The tumor weighed 6 lb., and measured 21 × 16 × 16 cm. The accompanying illustrations give a good idea of the clinical and pathological characteristics of the tumor.

The convalescence was entirely uneventful. The drain was removed within forty-eight hours and three weeks following the operation the patient was entirely free of pain and well able to use the leg.

Though adipose tumors of this size and even larger are quite commonly met with in the subcutaneous tissues they are extremely rare within the deeper structures. As far as their relationship to the surrounding muscles is concerned attempts have been made to classify them into intramuscular and intermuscular varieties depending upon whether the tumor is situated between individual muscles or muscle groups or whether it is confined within the belly of any one muscle. Since the characteristic qualities of the tumor remain identical in both cases it seems unnecessary to maintain any such artificial classification and the term deep-seated would be sufficiently descriptive of this type of growth.

The diagnosis of deep-seated lipomata is usually simple, if their long history, the absence of pain and fluctuation and their

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characteristically elastic consistency are noted. Some difficulty in their differentiation may be encountered in the thigh and the back where the overlying groups of muscles are large and palpation is difficult. In these locations adipose tumors may be mistaken for cold abscesses. The function of the overlying muscles will usually clear this point up, inasmuch as their contraction is normal in extent and painless over a fatty tumor and guarded, incomplete and painful over an inflammatory exudate. The occasion should never arise for exploratory puncture of such swellings for diagnostic purposes.

Histologically these deep-seated lipomata differ but slightly from the subcutaneous variety. The capsule is usually very well developed, the amount of fibrous tissue and the vascular supply are generally definitely increased. Their treatment is obviously surgical removal.

Case II. Mrs. C. H. white, thirty-four years old, was admitted to the Coney Island Hospital with the complaint of subsiding pain in the right lower quadrant of three days' duration accompanied by nausea, vomiting and constipation.

For the past ten years the patient had complained of a dull ache in the right lower quadrant, increasing on violent exercise and at night when lying on her right side. Occasionally this pain had been referred to the epigastrium and was then accompanied by nausea. Patient has always been somewhat constipated and has passed several blood-streaked stools within the past six months. Her appetite has always been good and her weight has remained constant. Both her marital and menstrual histories were negative.

Three days prior to admission to the hospital the patient experienced a severe pain in the right lower quadrant, and vomited once. Her temperature remained normal and her bowels moved twice that day. The stool was liquid but free of blood. Toward the evening of the same day the vomiting recurred, the pain increased and became cramp-like in character. A physician diagnosed an attack of acute appendicitis and ordered opiates and an ice bag. Next day she felt considerably improved. The stool was normal but the pain in the lower abdomen persisted all day. On the morning of the third day operation for subsiding appendicitis was advised by the attending physician,

Fig. 1. View of lipoma before operation.

whereupon the patient was admitted to the Coney Island Hospital.

She was found to be suffering considerable pain. The right lower extremity was held flexed. The head and chest were negative. The abdomen was soft except for the right lower quadrant where there was pronounced muscle spasm on palpation. The suprapubic area was soft and painless, whereas there was marked tenderness over McBurney's point. There was an indefinite mass palpable at this point which could not be outlined satisfactorily because of muscle spasm. Pelvic examination was negative. There was no vaginal discharge. Hemoglobin 85 per cent. Red blood corpuscles, 800,000; white blood corpuscles, 11,000. Differential count normal. Urine negative. Temperature, 99.4°F., pulse, 80, respiration 14. A preoperative diagnosis of subsiding acute appendicitis was made.

At operation the gall bladder was found to be soft, compressible and did not contain any calculi. The stomach, spleen and pelvic organs were normal. The cecum was glued to the parietal peritoneum and contained a mass about the size of a tangerine within its lumen. This mass did not pit on pressure, was elastic and was firmly attached to the posterior aspect of the cecum whereas the anterior wall of the cecum could be freely moved over the surface of the tumor. The ileocecal region was slightly invaginated into the ascending colon and was edematous. The appendix was normal in size,

color and position. There were no periappendiceal adhesions. Upon recognition of the tumor in the intestine the ileum was clamped off 8 cm. from the ileocecal junction. The cecum was mobilized by incising the peritoneum in the lateral lumbar gutter and clamped well above the tumor mass. Both bowel ends were closed with three layers of catgut sutures and an isoperistaltic anastomosis done. The abdomen was then closed without drainage.

The pathologist reported the tumor as a simple lipoma, submucous, having an area of necrosis about the size of a silver dollar on its free surface inside the lumen of the cecum.

FIG. 2. Tumor removed from Case 1. Note pressure furrow (arrow) of femur.

FIG. 3. Specimen of submucous lipoma of cecum. *a*, Area of necrosis. *b*, Mucosa of cecum. *c*, Mucosa of ileum.

The convalescence was entirely uneventful and at a reexamination six months later the patient was entirely free of abdominal symptoms.

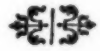
A total of 181 lipomata of the gastrointestinal tract have been described in the literature of which 16 only were confined to the cecum. The present case, as well as the two published by Ratcliff,[1] should be added to the previous ones bringing the grand total up to 184. The symptomatology of a benign tumor of the cecum in a quiescent stage is most indefinite. The obvious, outstanding symptom would be obstruction in its chronic, subacute or acute form. This may be produced by blocking of the lumen of the bowel by the tumor mass itself, if large enough, or by invagination of the bowel by constant traction in the line of peristalsis. In the latter form it would be reasonable to expect peritoneal reaction of a mild nature

[1] Ratcliff, R. A. Submucous lipoma of the colon. *Guy's Hosp. Rep.*, 80: 453, 1930.

in response to the continuous local circulatory disturbances. Thus a variety of gastrointestinal symptoms may appear, such as nausea, vomiting, constipation or diarrhea, none of which may be regarded as pathognomonic of benign tumors of the bowel. The diagnosis therefore cannot be anticipated on the history alone as it is possible in other gastrointestinal diseases. Palpation of a tumor and *x*-ray evidence of a filling defect in the cecum might help materially to make a definite diagnosis, but both of these signs can seldom be obtained. The patients seek relief usually when an acute calamity has occurred. We are then confronted with the picture of an acute obstruction in the presence of which few men are willing to order a gastrointestinal *x*-ray examination, or the peritonitis syndrome is in the foreground which effectually precludes detailed and successful palpation and *x*-ray study.

In the case described here an indefinite mass was made out at examination but it was attributed to the probable appendiceal exudate. Roentgenological examination did not seem to be indicated in the presence of a definite diagnosis of a subsiding appendicitis.

These cases have been reported because of their comparative rarity and for the purpose of recording them. From the second case, however, we have an important lesson to learn. That is, that a seemingly simple appendectomy, undertaken only too frequently by men of meager surgical experience, may turn out to be a formidable major procedure. It devolves therefore upon every surgeon wishing to do justice to his patient to be prepared to make an intra-abdominal diagnosis of any unusual pathological condition and to be competent to carry out the indicated major procedure.



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[For remainder of References see p. 528.]

* Continued from p. 521.

SPONTANEOUS GANGRENE OF SCROTUM & PENIS*

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BROOKLYN, N. Y.

AN acute fulminating gangrene of the scrotum and penis is characterized by an abrupt spontaneous onset, a rapidly ensuing inflammation with marked edema and subsequent necrosis of the superficial tissues of the genitals (Campbell).

The object of reporting this case is to show the rapid invasion and wide destruction of tissues and the marked general sepsis which frequently causes a fatal termination. Early recognition of this entity and understanding of the anatomy of the fascial planes where the infection travels, multiple incisions and drainage which were instituted in this case, were all factors to which we attribute the complete recovery of this patient.

The following case history is that of patient D. K., a male, married, thirty-six years of age, admitted to the Israel-Zion Hospital on February 5, 1930. His previous history was negative except for his having been "gassed" during the world war. The anamnesis is as presented in the following history.

Feb. 1. Sudden onset, with chills, fever, headache, general body pains, perspiration and weakness. There were also dragging pains in the scrotum within twenty-four hours. Temperature 102.5°F. There was a scab on the left side of the scrotum, removed by the patient and leaving a small raw surface.

Feb. 2. There were severe pains and tenderness in the left side of the scrotum with a small area of redness which was rapidly spreading and was tense and shiny. The scrotum was increased in size.

Feb. 3. The process spread to the right side involving the entire scrotum and the base of the penis which became considerably edematous. There was no sharp line of demarcation. The color was dusky.

Feb. 4. There was an advancing wake of lymphangitis spreading to the inguinal and perineal regions. The scrotum was swelling, becoming more tense, shiny and edematous. The epidermis was sloughing in chunks and there was a serous exudation from the underlying edematous tissue, "a weeping." The color was the typical dark gray of gangrene with its putrefactive odor. No crepitation however was palpable. There was moderate prostration and the temperature was 101°F. and the pulse rate 112.

Feb. 5. The changes were progressively worse. The scrotum was the size of a grapefruit. The penis was increased to more than three times its normal size. The lymphangitis invaded the lower abdomen and ischiorectal regions which were becoming more tender.

Feb. 6. The patient was operated on by Dr. Linder under nitrous oxide-ether anesthesia. Multiple long, deep, and sweeping incisions were made on either side of the scrotum, ischiorectal and both inguinal regions, exposing the spermatic cords. In making these incisions, it was noted that the skin was gangrenous, the subcutaneous tissue edematous and that a thin yellowish fluid oozed out. The fascia was observed to be sloughing in its entirety.

The postoperative course was stormy. The patient showed signs of prostration. The blood count was red blood corpuscles 2,170,000, Hb 48 per cent (Sahli), white blood corpuscles 19,100 and polymorphonuclears 71 per cent. A small blood transfusion sent the patient's condition up, temporarily, until he received another blood transfusion subsequently. The temperature dropped from 104.8°F. until it fluctuated between 99 and 102°F. The wounds suppurated, extended gradually by fascial continuity, until one wondered if the process invaded the abdomen or when the spreading infection would cease? When the penis was denuded except for the glans and corpora cavernosa and the scrotum had been entirely destroyed there was extension into the inguinal regions which gaped and allowed the testicles to hang "dangling" by their spermatic cords except for their covering of tunica vaginalis. Then the destruction stopped. This occurred only after two sudden hemorrhages from thrombosed vessels between the base of the

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penis and the testicles, which were clamped to control excessive hemorrhage.

The process of regeneration then took place.

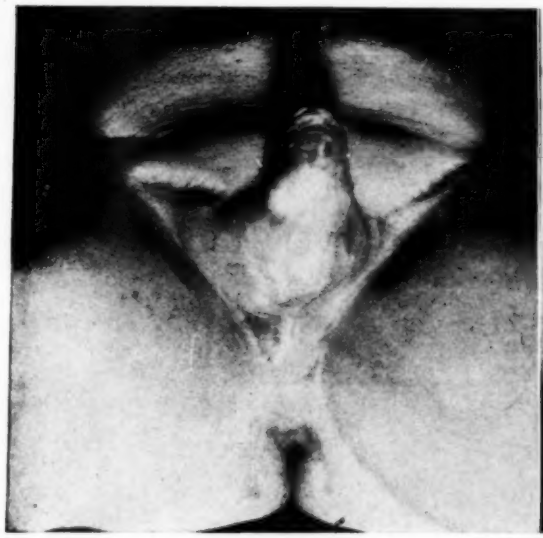

Fig. 1.

Fig. 2.

Figs. 1 and 2. One year after recovery. Showing new and smaller epithelial scrotal sac. Narrowed caliber of penis. Postoperative scars.

Both testicles were intentionally coapted. They matted together and soon were covered over by new epithelial tissue bridging over to form a new scrotal sac which was smaller than the original and of a purplish color, making skin graft unnecessary.

Pathological Anatomy. The fascia which was destroyed invaded the following anatomical structures. From the scrotum it extends to the dartos which is the tunic of the scrotum and is a thin layer of vascular tissue continuous with the superficial fascia of the groin and perineum. This fascia then dips down into the median line or raphe, which divides the scrotum into two lateral portions and is continued forward to the under surface of the penis and backward along the middle line of the perineum to the anus. It then involves the penile fascia (the fascia of the dorsum of the penis) and then continues into the abdomen as the deep layer of the superficial fascia (Scarpa's fascia). It then involves the fascia of the urethral surface of the penis, the dartos and the scrotum and extends posteriorly to invade the deep layer of the superficial fascia of the perineum (Colles's fascia) and then into the ischiorectal region.

Bacteriology. The organism isolated is a strain of the Streptococcus hemolyticus. No anaerobic organisms were isolated. We believe this gangrenous process to be due to a special strain of the Streptococcus hemolyticus with unusual virulence, spreading through the lymph spaces and having a predilection for the invasion of superficial blood vessels and fascia.

The skin passes through an early red stage followed by a brownish, glistening discoloration with no sharp line of demarcation, which differentiates this from erysipelas, to that of a dark gray or green when the gangrene has been thoroughly established. Then comes lymphangitis, fascial destruction, suppuration and finally epithelization.

Treatment. Incisions are made as soon as the diagnosis is established. We inserted Dakin tubes into the wounds and irrigated with Dakin's solution and later applied potassium permanganate soaks. We also gave the perfringens antitoxin. Other treatments were supportive.

Course. The sudden "explosive" onset with grippal symptoms, a small red area

on the scrotum, hastily progressing to the considerable enlargement of the scrotum and penis and an apparently comfortable condition of the patient, until soon the patient shows symptoms of the severe toxemic absorption of the necrotic products, along with exhaustion, low red cell count and hemoglobin, is striking if not dramatic.

The complete destruction of the scrotal sac, with two homeless testicles, a denuded penis with only its glans and an adjoining collar of skin, two spermatic cords hanging freely from the external inguinal rings, are the price of bacterial invasion. A new scrotum, smaller in size but sufficient to hold the testicles, new skin to cover the deficiency of the penis and narrow its caliber, are the ultimate results.

At present, one year after recovery, the patient has been in good health and his sexual powers have been entirely preserved.

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CYSTS OF THE PROSTATE*

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NEW YORK

CYSTS of the prostate are rare, if we are to judge from the comparatively small number of cases that have been reported. To this number, I wish to add another.

This patient was a man fifty-four years of age, who complained of dysuria, frequency and straining to begin his urinary flow. His illness was of one month's duration. He voided every half-hour during the day and four or five times during the night. He had no hematuria and said his urine was clear. His general physical condition was good.

Rectal Examination revealed a prostate that was not enlarged, smooth, symmetrical and not tender.

Laboratory Findings: On admission:

Non-protein nitrogen	50
Creatinine	2.7
Phenolsulphonphthalein	
First hour	10
Second hour	5

After several days with indwelling catheter:

Non-protein nitrogen	35
Creatinine	1.4
Phenolsulphonphthalein	
First hour	30
Second hour	15

Urine analysis: negative except for a few scattered white blood corpuscles.

Flat *X*-ray plate, negative.

Blood pressure, 120/80.

Cystoscopic Examination: A No. 24 Brown-Burger cystoscope was easily passed; 120 c.c. of residual urine were obtained. The bladder was slightly trabeculated. There appeared to be an intrusion of the right lateral lobe with a definite sulcus at seven o'clock. The right lobe then extended over, narrowing the outlet. There was a very slight bas-fond. Practically all of the trigone was visible and both ureteral orifices appeared normal. A preoperative diagnosis of prostatic obstruction was made. A suprapubic operation was advised. This was done in the classical fashion.

Operation: The bladder was opened widely so that a satisfactory exposure of the vesical neck could be obtained. An intrusion at the upper right part of the internal meatus was seen, about the size of a large cherry which acted as an obstruction. This obstruction transmitted the light of a Cameron lamp brightly and it was decided that the obstruction was due to a prostatic cyst. Upon attempting to remove it the cyst was ruptured with the evacuation of a viscid fluid. All this tissue was then resected away and with a Young's punch the vesical neck enlarged.

Pathological Findings: By Dr. Symmers. The resected portion was reported as mainly connective tissue, evidently pieces of cyst wall.

The patient made an uneventful recovery and was discharged from the hospital in three weeks, with no residual and no urinary difficulties. He was recently examined, sixteen months after his operation and has no urinary difficulties.

The pathology of this entity divides cysts of the prostate into three classes.

1. *Congenital Variety:* Cystic dilatation of the remnant of Mueller's duct which is the homologue of the vesicuola prostatica or sinus pocularis. The utricle being a remnant of Mueller's duct has no genetic relation to the prostate gland or the seminal vesicle. Congenital defects of this organ may result in cysts. Cysts of this type are unilocular and may obtain considerable size. Spinger found two cysts of the sinus pocularis in autopsies on 62 male children who died soon after birth.

2. *Acquired Cysts:* Cysts dependent upon an obstruction of the prostatic duct with retention of secretion. Le Dentu believes these may be formed by the coalescence of several dilated aceni.

3. *Echinococcus and Dermoid Cysts:* The third and most rare group of cysts. The primary cysts of echinococcic origin in the prostate are a questionable entity but several cases have been reported which were believed by their authors to be primary infections.

The symptoms are those caused by mechanical obstruction to urination and the treatment depends on the making of the diagnosis and the variety of cyst.

* Read before the Section of Genito-urinary Surgery, New York Academy of Medicine, April 15, 1931.

SARCOMA OF KIDNEY SIMULATING SOLITARY CYST*

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NEW YORK

THE patient whose history is presented was a man fifty-eight years old, when examined in February, 1930. The chief complaint was constant dull pain in the left flank radiating into the groin and testis. On examination there was found a mass, globular, elastic and movable, in the left kidney area; a left varicocele with atrophy of the testis. The urine contained a trace of albumin, occasional leucocytes and erythrocytes. Cystoscopic examination revealed moderate enlargement of the lateral prostatic lobes into the posterior urethra. There was good efflux of indigo carmine from the right ureteral orifice, no obstruction or retention. The left orifice was very small, no efflux seen. After some manipulation a No. 4 *x*-ray catheter was passed and 10 c.c. of clear urine aspirated from the pelvis, with traces of indigo carmine.

FIG. 1.

A plain roentgenogram disclosed a sharply outlined globular shadow occupying the region of the lower pole of the left kidney. Injection of 20 c.c. of 12.5 per cent sodium iodide showed a dilated pelvis and enlarged blunted calices. The lower half of the pelvis seemed to cast a much less dense shadow than the upper half, suggesting compression by the mass. The lowermost calices while somewhat bizarre in shape presented no filling defect. The globular shadow was again visualized (Fig. 1). The diagnosis made was solitary cyst of the lower pole of the left kidney with compression of the renal pelvis and pyelectasis.

FIG. 2.

The patient was seen by Dr. A. R. Stevens who inspected the films and agreed that the diagnosis was to be seriously entertained, although some other type of tumor could not be absolutely excluded.

Operation was performed on March 17, 1930, under spinal analgesia, 120 mg. neocaine in the second lumbar interspace, satisfactory. The usual oblique lumbar incision was made, Dr. Edelman assisting. There was an unusual degree of inflammation of the perirenal and peripelvic fat. A solid tumor mass occupied the lower pole. Nephrectomy was performed. After the organ was ablated I noted a small elastic protrusion felt through the posterior muscles (psoas and quadratus lumborum) which was interpreted as a metastatic deposit. When the specimen was opened the tumor was extremely firm, greyish yellow with an area of

* Read before the Section of Genito-urinary Surgery, New York Academy of Medicine, April 15, 1931.

necrosis and hemorrhage. Radiating fibrous strands traversed it (Fig. 2). It appeared to me to be a scirrhous carcinoma. Great was my surprise when the pathologist, Dr. Klemperer, reported it to be a granuloma. If inflammatory, syphilis had to be considered but both Wassermann and Kahn tests proved negative.

Fig. 3.

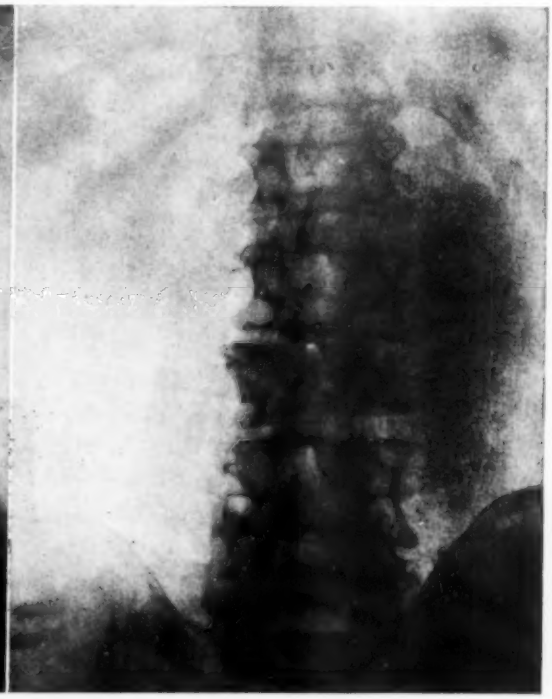

Fig. 4.

Convalescence was uncomplicated, but the patient continued to have some discomfort in the lumbar region. On July 8, 1930, there was noted definite lateral curvature of the lumbar spine and *x*-ray examination revealed an area of absorption in the left upper quadrant of the third lumbar vertebral body (Fig. 3).

Deep radiotherapy was begun by Dr. William Harris and a Knight spinal brace was fitted by Dr. Seth Selig. Subsequently a mass was detected deep in the left lumbar fossa. About this time the slides were submitted to Dr. Goldzieher who diagnosed Hodgkin's disease. An *x*-ray of the spine November 8, 1930, showed definite compression deformity of the third lumbar vertebra (Fig. 4). I therefore concluded that the process was undoubtedly malignant. As the histological features simulated an inflammatory lesion I felt that the primary renal disease was sarcomatous. In this opinion Dr. Francis Carter Wood concurred and upon his advice transfusion and resumption of radiotherapy were undertaken.

On February 28, 1931 *x*-ray examination of the spine showed more marked compression of the third lumbar vertebral body but considerable new bone formation (Fig. 5). There were no evidences of metastasis elsewhere. Roentgenography of the chest was negative.

Fig. 5.

A small mass may still be felt to the left and in front of the spine, and the interference with posture and gait is persistent. Secondary anemia is also present.

THROMBOANGIITIS OBLITERANS OF THE UPPER EXTREMITY*

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CLEVELAND, OHIO

THROMBOANGIITIS obliterans, also commonly known as Buerger's disease, is a disease of young or middle-aged adult males; characterized by progressive development of symptoms referable to impaired circulation locally, most prominent among which are numbness, coldness, and intense pain; and results frequently in mummification and loss of the parts affected and eventual healing in proportion to the ability of the part to establish a collateral circulation. As originally described it was regarded as almost exclusively a disease of Jews and thought to be confined to the lower extremities. More recently it is coming to be recognized nearly as frequently in patients who are not Jews. It has also been found in other parts than the lower extremities, particularly end arteries. The greater frequency in the lower extremities is probably due to their dependent position. Involvement of the upper extremities is mentioned by Buerger and Constam but the only cases in the literature of recent years in which the upper extremities were affected primarily are four reported by Constam from cases seen at the Mayo Clinic.

The following case report is that of a presumably early thromboangiitis obliterans primary in the upper extremity without involvement elsewhere:

M. Y., aged forty-four, male, white Gentile of British parentage, married, presented himself as an industrial commission case on Nov. 22, 1930. His complaint was that of numbness and tingling in the tip of the right index finger; distinct coldness of that digit; and later increasing pain until he could not sleep at night. The time of onset was rather vague but the symptoms had progressively increased during the past three or four weeks. He was inclined to attribute his symptoms to the bruising of his finger against a milk bottle, tearing the nail slightly from its bed on the radial side with the possible entrance of a small glass fragment.

Past History: Always in good health. Had gonorrhea as a young man without complications other than venereal warts on the ventral surface of the penis which required removal. He had no knowledge of any luetic infection. Had had frequent examinations at his place of work including blood Wassermann tests. These tests he insisted had always been negative and we likewise received the same report from a specimen we sent to a laboratory.

He began smoking at the age of fifteen and has smoked heavily ever since. Served in the Navy as a young man. For past eighteen years has been employed at outdoor work delivering milk to retail stations. Work has consisted of handling heavy cases in the early morning hours (mentioned because of the possible significance of the fact that it is the coldest part of the day); often has abraded and bumped fingers at work. Extremities have never been frost-bitten but have gotten extremely cold on a few occasions; have required application of snow to restore normal feeling; and pain was so great that it brought tears to his eyes.

Diet: In the Navy, he was fed plain staple foods in a balanced ration. In civil life, he has eaten varied foods; different kinds of bread including rye, and cereals, but no one predominating or outstanding article of food.

Marital History: Wife living, always healthy, no miscarriages. Has four living children; always healthy, no deaths.

Examination showed a nervous apprehensive individual whose right index finger seemed unduly tender and sensitive out of all proportion to the visible signs. The distal phalanx appeared very slightly swollen but was not tense. A small patch about size of the flat surface of a split pea over the distal fat pad, slightly to the radial side, was dry and more cornified than normal epidermis. The possibility of a circulatory disturbance was considered quite

* Submitted for publication August 10, 1931.

strongly but in order to give full weight to his claim of injury, the possibility of an infection also had to be entertained and so moist bichloride dressings were applied.

The pain was not relieved and three days later a slight serous discharge just to the radial side of the nail suggested a foreign body reaction. Under local anesthesia, a small longitudinal incision was made just lateral to the nail margin but no foreign body or evidence of infection was found.

Under subsequent treatment with moist bichloride dressings and then ammoniated mercury ointment dressings, the distressing symptoms subsided but the wound remained indolent. There was never any suppuration; only a dark necrosis of the wound edges. After about three weeks the wound was left dry and mercurochrome applied but an exacerbation of pain occurred on Dec. 24 of such severity that opiates were necessary for relief. On Dec. 27, an *x*-ray examination showed that the greater part of the distal phalanx had been absorbed and that an isolated small sequestrum was present under the lateral margin of the nail. This sequestrum came away about two weeks later and prompt healing followed. He was last seen for that illness on Jan. 31, 1931. The wound was healed with loss of substance on the radial side of distal phalanx and retraction from the lateral margin of the nail. The epidermis of the finger end remained very dry and horny.

On March 3, 1931, the patient returned complaining of intense pain in his right middle finger. He attributed his condition to an indefinite injury which he placed at about Feb. 25. There had again been distressing paresthesias along with the pain. He had resorted to home remedies without relief.

Examination showed an edematous swelling of the distal half of the right middle finger with an eczematoid lesion about the nail characterized by brownish scales and exudation of serous fluid. There was distinct paleness and coldness of that digit.

It was now felt with more certainty that this was a circulatory disturbance of the nature of a thromboangiitis obliterans. However, the alleged trauma could not be disregarded. Wet dressings of Dakin's solution were applied and abstinence from tobacco urged. This had previously been suggested to him but this advice was never very faithfully carried out.

The pain and sensitiveness to touch remained so that he was unable to work. He required opiates in order to get any sleep. Most of the month of March he was compelled to sleep sitting up in a chair, often finding it necessary to hold his hand up above his head for relief. On March 10, the tip of the finger and the nail bed had become definitely gangrenous. His blood pressure on that day was 130/80. Dressings with an ointment containing butesin picrate were resorted to and gradual improvement followed. A definite line of demarcation developed and by the end of March most of the swelling was gone and the pain was very much less. A black slough developed, liquefied rapidly, and disappeared. At the end of April, the wound was dry with the end of the terminal phalanx protruding but still firmly attached. Only a small corner of the nail remained and nearly all of the nail bed was gone. The patient returned to work May 5 and after about one week some discharge appeared about the exposed bone. This bone became detached so it could be removed on May 19. Prompt healing followed. Only small crusts and parts of the nail came away for the few days we continued to see the patient. When the patient was last seen about two and one-half months later, both fingers had quite serviceable ends and quite a good deal of regrowth of the nail and nail bed of the middle finger had occurred.

During the course of the last illness, careful external examination failed to reveal any evidence of a cervical rib which might be productive of a trophic disturbance. To tactile sensation, both the radial and ulnar arteries appeared to pulsate with undiminished force at the wrist. The urine analysis was negative on two occasions.

Summary: A middle-aged adult male, a Gentile, appeared with symptoms of impaired circulation in the right index finger thought to follow what would be an inconsequential trauma to the usual individual. The outstanding feature was severe pain. The process went on to gangrene of the terminal part of the finger with prompt healing following loss of substance. This process was repeated soon in the middle finger. No evidence of arteriosclerosis, lues, diabetes, or other source of trophic lesions was found. Hence we conclude that clinically this was a case of thromboangiitis obliterans primary in the upper extremity.

CHOLECYSTECTOMY

A REFINEMENT OF TECHNIQUE*

R. W. LAGERSEN, M.D.

MINNEAPOLIS, MINN.

AMONG the various factors which may result in successful surgery, we are concerned today with the minimum of operative trauma, proper peritonealization of raw surfaces and refinements in ease and speed of procedures. The method of serosal dissection in cholecystectomy as described later offers this triad and is applicable wherever the serosa overlying the gall bladder is not densely agglutinated to the underlying tissues.

Suitable exposure having been made, the gall bladder brought into the operative field and the duct clamped in the usual manner, a solution of normal saline is injected subserosally at the fundus and downward bilaterally in the line of usual incision. A long fine curved needle of very short bevel will be found most advantageous. As the serosa lifts in response to fluid pressure, the point of the needle is advanced along the line of subsequent incision; it will be found that the serosa is well lifted from the muscularis in the line of incision and that the greater part of the serosal dissection has been done by the fluid thus injected. The serosa is then picked up, snipped, and the incision down both sides and over the fundus is easily accomplished with scissors.

This method of dissection of the serosa may be carried out with the duct clamped or not, but is of course done with greater facility if the duct has been previously clamped. Obviously, if the gall bladder is half-empty, the muscularis will be displaced to the interior of the gall bladder more than the serosa is lifted. If the gall bladder wall is under the tension of the contained bile, the serosa is ridged up prominently along the line of injection, since the greater the pressure within the gall bladder, the greater the hydrostatic power of the subserosally injected solution.

This method will be found to offer the following advantages:

1. The serosal dissection is done to a great extent by the injected fluid, and trauma from instrumentation is therefore at a minimum.

2. There is practically no danger of the interior of the gall bladder being invaded in any subsequent necessary dissection, since the serosa is already lifted.

3. Very even serosal margins are offered for peritonealization of the gall-bladder bed.

4. Since serosal dissection is tedious and time consuming, this method offers ease and speed of procedure, with a wide margin of safety.

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* Continued from p. 512.

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EDITORIALS

ANESTHETIC PROGRESS BY INTEGRATION

WITHIN the last six months, a personal inquiry was addressed to the Surgical Directors of fifty-three of the leading hospitals in Greater New York, with a view of securing light on the following facts relating to anaesthetic service. These hospitals in this metropolitan area furnish, it is felt, a fair cross-section of the hospitals throughout the country, for the reason that this group is more or less free from the influences which give rise to so-called gas sections on the one hand, and open ether sections on the other. The inquiry was couched in the following broad terms, asking information concerning three groups of facts:

"In your employment of general anesthesia for abdominal surgery, upon what technique do you largely depend—spinal or general anesthesia?

"If general anesthesia, what is your chief anesthetic agent, ether, gas oxygen, or ethylene?

"Have you found it desirable to use preliminary medication, such as morphine, atropine, sodium amytal, or avertin?"

Forty-one replies were received to these fifty-three inquiries. A fairly large percentage indicating considerable general interest.

In reply to the first question, 4 surgeons reported their chief dependence upon

spinal anesthesia; 35 used "general," and 2 showed no preference.

In round figures, 10 per cent depended upon *spinal*, and 90 per cent upon general anesthesia.

In answer to the question: Upon which agent do you chiefly depend? 2 were in favor of ethylene, 3 gas-oxygen, 3 gas-oxygen and ethylene, 2 institutions made a practice of using gas-oxygen with a little ether, 19 preferred the gas-oxygen ether sequence, and 10 institutions were in favor of ether. The hospitals reporting a preference for spinal anesthesia did not express a choice for a general agent. To summarize, 5 per cent preferred ethylene, 15 per cent gas and oxygen, and 80 per cent felt that they were better off with more or less ether for their abdominal surgery.

Referring to the use of preliminary medication of the 37 who reported: one used no medication; 2 preferred avertin; 4 used morphine, atropine and avertin; 5 used morphine, atropine, and sodium amytal; one used scopolamine; 6 used morphine; and 17 used morphine and atropine.

To summarize, approximately, 97 per cent used preliminary medication; of this percentage, 35 per cent made use of the newer basal anesthetics—sodium amytal and avertin. The larger number, however, employed the customary preliminary morphine with or without atropine.

In view of the conclusion to be drawn from this inquiry; namely, that 90 per cent of abdominal surgery is done with general anesthesia, in approximately 80 per cent of which general anesthesia ether is employed, preceded in almost every instance by preliminary medication, may we not properly inquire: Does instruction in ether anesthesia and a knowledge of its action correspond with the popularity of its usage? Should we concentrate upon instruction directed to better, safer, ether anesthesia, or should we look upon this usage, as typical medical ultra-conservatism, devoting our energies, therefore, to the elimination of ether as a general anesthetic?

The writer believes that there is a strong tendency to follow, or shall we say, retain, the gas-oxygen ether sequence in abdominal surgery. Whether this tendency is due to an ignorance of the value of the newer anesthetic agents and sequences, or whether it is the result of the unfortunate experimental use of agents which have been proposed as panaceas, is a question which has not been answered. Furthermore, are the conclusions arrived at based upon the findings of a specially trained and selected personnel, or upon the service rendered by anyone in the house who happens to be able to give an anesthetic?

These questions and others would have provided a questionnaire of valuable content, but practically useless, since, human nature being what it is, these questions would not have been answered.

Upon the facts presented, however, may we not propose a thought, a watchword, a point about which substantial and legitimate improvement in anesthesia may turn? May we not apply to the disorganization in anesthesia which we see about us the sound philosophy of integration; the orderly accumulation of knowledge and experience, and its universal and practical application; in contradistinction to the continual and wholesale elimination and substitution of the tried and the true which has come to be looked upon as medical progress.

Hundreds of thousands of anesthetics administered and studied during the last ninety years have made available a body of knowledge which must be respected and in justice consulted in estimating the real value of new agents and methods of administration. In the absence of this fundamental knowledge, we are entirely at the mercy of any force or group proposing a new agent or a new method.

Without a knowledge of the clean-cut, fundamental requirements of good anesthesia, in their normal sequence of safety, efficiency, and freedom from unpleasant

effects, we cannot be expected to make and to encourage the sacrifice which a rational choice entails. We will either fall into the error of sacrificing safety for the surgical ease of the routine spinal anesthesia (post-mortem abdomen), or, we will yield to the patient's plea for the minimum postoperative discomfort, reducing thereby the margin of anesthetic safety, and working against rigid muscles and active reflexes.

No one, of course, objects to the prudent employment of newer agents and methods where definite indications present themselves. It is the naive adoption of extremes as an institutional routine to which exception is taken.

If it is true, as stated by Miller, that it is unlikely that a healthy patient has ever lost his life from ether properly administered, it is doubtless true also that any other anesthetic administered with the gross negligence with which ether has been administered would long since have been discarded; and if it is also true that the long use of ether has enabled us to become better acquainted with it than with any other anesthetic agent, is it not of fundamental importance that these facts be recognized in the management of our anesthetic services? Does it not follow that, as a fundamental requirement to anesthetic instruction every one should be taught ether anesthesia?

Upon the solid basis of safety and efficiency raised by time and experience, we may safely and with profit integrate the newer facts of anesthesia. We may then use our available gases, nitrous oxide, oxygen, ethylene, and carbon dioxide; our basal anesthetic agents, morphine and atropine, scopolamine, sodium amytal, avertin, and pernocton; our local and spinal methods, with novocaine, nupercaine, and the other drugs available.

Integration makes use of the personnel administering anesthetics. In well-organized medical groups, with a large volume of material susceptible of routine treatment, the technician is useful and safe. Intelligent direction and responsibility for the anesthetic, the practical integration of all the facts of a given case, may here be adequately met and safety preserved by the operating surgeon; for medical judgment, direction, and legal responsibility are neither sought nor desired by the technical group. The employment of a nurse to give an anesthetic presupposes an intimate knowledge of anesthesia on the part of the surgeon.

The man who makes use of technical assistance outside of a large well-organized institutional group must be trained to meet his responsibility for the correct choice of agent. He must have a knowledge of its action and be prepared to direct treatment in emergencies. In the absence of such information, he is obligated to protect his patient by providing this service.

The integration of anesthesia involves also all forms of instruction, that to the surgeon, medical student, interne, general practitioner and nurse. It directs the course of research and experiment. Its conclusions are made upon a basis of justice to the patient, the surgeon, and the anesthetist, prudence in the approach to risks, a temperate enthusiasm for untried agents, and a steadfastness in doing what is right, regardless of opposition or reward.

It is well to keep constantly before us the fact that a drug which will destroy consciousness, muscle tone, and reflexes, is a dangerous drug; that its use as an anesthetic agent does not reduce this danger, but increases it, and that its employment by a surgeon for 5000 operations without a death should not satisfy us that it is safe in other hands, and under other conditions. It may therefore be reasonably concluded that if the hoped-for ideal anesthesia were discovered tomorrow, it would be forced to prove itself over years of use.

May we not, therefore, with profit turn our attention, as we strive for improvement, to an evaluation of our present possessions?

Is it not incumbent upon us to provide facilities for serious instruction in anesthesia; to provide adequate training in anesthesia for the medical student, interne, general practitioner, nurse, and last, but by no means least, the surgeon who employs and depends upon the services of a technician?

The first step in the training of the student is a recognition on the part of the medical schools and the hospitals of the dignity of anesthetic obligations, the recognition that this practice is the most critical and dangerous branch of therapeutics. Following this improvement in morale, may we not insist that a knowledge of ether be acquired before the student makes use of the gases, the basal anesthetics and the available local methods?

For the men who have completed their student days and who are now practicing surgery, instruction should be available in the form of post-graduate information, presented with a dignity, an understanding and a maturity of viewpoint in keeping with the experience of the man seeking instruction.

In conclusion, therefore, it is suggested that true improvement and progress in anesthesia can best be achieved by integration; by the correlation and practical application of anesthetic knowledge and experience in its correct sequence.

As a primary means of affecting this integration, an attempt should immediately be made to improve the standing of anesthesia as an art. Adequate and serious instruction should be planned, and should be provided for the medical student, interne, general practitioner, nurse and the uninstructed surgeon who makes use of technical assistance.

Paluel J. Flagg.

NOTICE

At a recent meeting and examination of the American Board of Obstetrics and Gynecology held in New Orleans on May 10, 1932, fifteen applicants were accepted for certification. Three failed to obtain the required grades.

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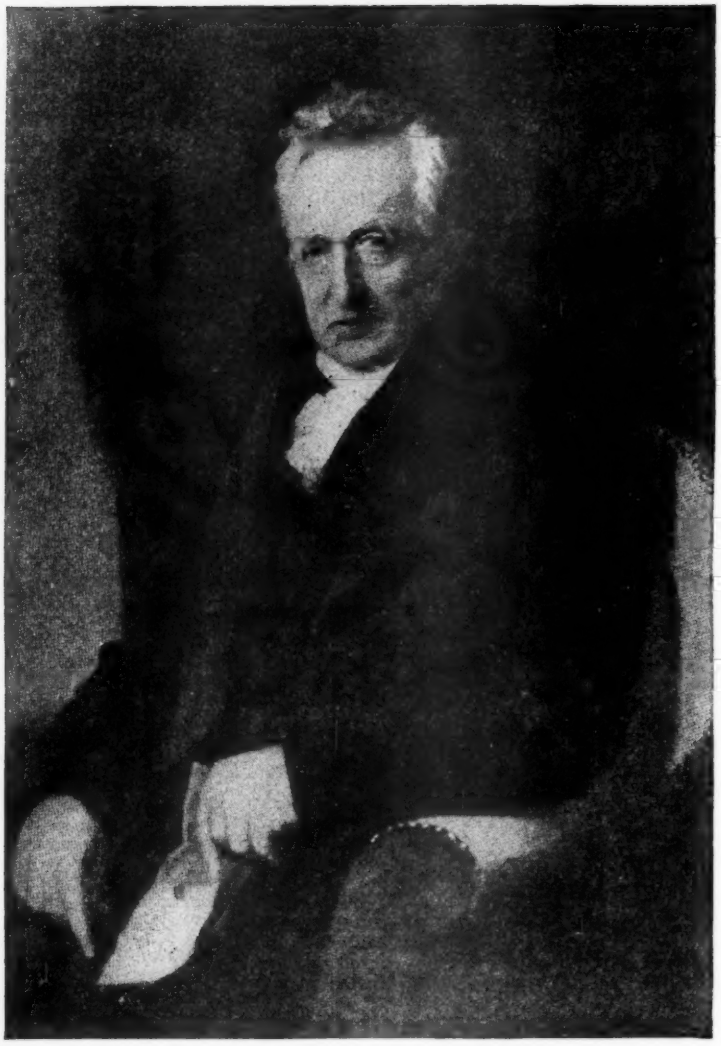

NATHAN SMITH

[1762-1829]

The American Journal of Surgery
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AMERICAN PHYSICIANS

NATHAN SMITH

NATHAN SMITH was born in Reho-both, Mass., September 30, 1762. He was "one of the great pioneers of American medicine, and during his active life was the omnipresent genius in New England medicine."

He taught in the local rural school. During this time Dr. Josiah Goodhue of Vermont visited the neighborhood to amputate a leg and Nathan acted as a lay assistant. This awoke a desire to study medicine. The Reverend Whiting of Rockingham, Vt., became his tutor. In 1784 he presented himself to Dr. Goodhue as a private student and remained three years. At the age of twenty-five he began to practice (1787) in Cornish, N. H., without a medical degree. He attended several courses of lectures at the Harvard Medical School and received his degree of Bachelor of Medicine (1790), the fifth student to graduate from the Medical School in the third class of that school. His M.D. was conferred on him automatically in 1811.

In 1791 he married Elizabeth Chase. She died in 1793 and the next year he married her half sister. Two sons were born of this marriage.

While practicing in Cornish he was impressed with the meager facilities for medical education. In 1796 he attempted to start a medical school at Dartmouth College, but failed. Smith then went abroad and studied in Edinburgh and London. Soon after his return in 1797 he was awarded a diploma from the Medical Society of London. He also became a corresponding member.

In the Fall of 1797 he delivered the first course of medical lectures at Dartmouth. In August, 1797, the trustees established a medical department with Smith as professor of anatomy, surgery, chemistry and physics. Oliver Wendell Holmes said it was not a chair but "a whole settee of professorships." Thus the fourth medical college in the United States was founded. In 1821 he was asked to establish a medical department at Yale. He accomplished this in the face of many obstacles. He did the same for Bowdoin College (1820) and later for the University of Vermont.

He was never a voluminous writer, although his essay on typhus fever (1824) and his observations on necrosis (1827) are still memorable.

He operated for amputation of the knee joint, performed the second ovariotomy in the United States, and did the first staphylorrhaphy. But he will be known as a great teacher and organizer.

He died at the age of sixty-seven years in 1829.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

THE INTERESTS OF A UROLOGIST IN 1880*

EDWARD L. KEYES, M.D., F.A.C.S.

NEW YORK

BERGSON has called attention to the profound fact that in life and thought as in time there is no such moment as now and in particular that the crystallization of our thought in words kills it. Many think the same is true of art and seek the sketch rather than the finished product, feel indeed that Michael Angelo showed himself almost unique in the wisdom that bade him stop his work where inspiration ceased.

Yet even in writing there are moments which are sketch-like and share the eternal vitality of the artist's sketch. Such items present the momentary interests of the author's mind and here it will be a pleasure at least to the writer of this paper to transcribe, with an egotism which he hopes may be found pardonable, the notes contained in an interleaved textbook in his possession which was being made ready for its second edition by the author just fifty years ago.

The book which is our text is entitled, "A Practical Treatise on the Surgical Diseases of the Genito-Urinary Organs, including Syphilis. Designed as a Manual for Students and Practitioners, by W. H. Van Buren, A.M., M.D., Professor of the Principles of Surgery, with Diseases of the Genito-Urinary System and Clinical Surgery, in Bellevue Hospital Medical College; Consulting Surgeon to the New York Hospital, The Bellevue Hospital, The Charity Hospital, etc.; and E. L. Keyes, A.M., M.D., Professor of Dermatology in Bellevue Hospital Medical College; Surgeon to the Charity Hospital Venereal Division; Consulting Dermatologist to the Bureau of Out-door Relief, Bellevue Hospital, etc." This is the first edition, published in 1874.

The annotations are in the hand of Keyes and seemingly written in the late 70's or about 1880, judging from the dates of the authors cited.

There is but one exception, signed "V. B.," which reads as follows:

> In a gouty man of 66 from whom I removed a vesical calculus by lithotrity after much complaint of local pain, at first recorded as lumbago, fluctuation was detected over the right kidney behind. After exploration* it was opened and a moderate amount of thin pus escaped with relief from the pain. A fistulous opening

* Presumably with a trocar.

* Dr. Keyes read a chapter on "Early Urology in New York" from a forthcoming book to be published by the American Urological Association, before the New York Society, Feb. 24, 1932. To this he adds the following comment. Ed.

remained for some weeks. Within the year he died with symptoms of uremia from Bright's disease. H. Munsell attended him with Lente of Cold Spring in 1871.

Of the multitude of notes in my father's handwriting it seems appropriate to give only a few selected examples to show the state of mind of an inquiring urologist on certain topics at that date.

Of first importance in those days was infection as is illustrated by the following quotation.

Pasteur who maintains that without bacteria urine does not decompose, overthrew (*Comptes rendus de l'Acad. des Sci.*, July 23, 1877) Bastian's experiments, showing that the fallacy of the latter consisted in his not having purified his flasks by heat. The liq. potassae, the urine and the flasks must be so purified to make an experiment valid. Pasteur and Joubert (*Journal de Pharmacie et de Chirur.* Sept. '76, 206) repeating some experiments of Musculus prove that the soluble ferment procured by the latter from ammoniacal urine which is capable of changing urea and water into carbonate of ammonia, is the product of bacteria since ammoniacal decomposition does not occur without the latter.

P. Cazenave and Ch. Livon ligated a dog's prepuce, allowed bladder to fill, then killed dog and tied ureters and urethra. Bladder was removed and kept exposed to air for several days at temperatures varying from 80° to 122°F. The experiment was several times repeated but organisms did not appear in the urine whatever its original reaction had been nor did it decompose. (The urethra is full of bacteria—Keyes.)

The following quotation illustrates the difficulties that beset the practical mind in determining the importance of bacteria in infection of the urinary organs.

Moreover bacteria may exist in bladder and not create cystitis or ammoniacal changes in the urine at all. During winter and spring of 1878 I kept unprotected on my office table for six (at least) months very acid urine, loaded with pus, passed like gruel from a child with pyelitis. I frequently opened and examined the bottle and although bacteria developed in it abundantly (active rods, etc.) no ammoniacal changes occurred, the urine did not decompose, the pus did not become gelatinous. I have several times had patients who habitually passed phosphatic urine (earthy) containing bacteria (but no pus) in whom there was no cystitis whatsoever.

At that period too the sharp reaction to the passage of urethral instruments in patients who had suffered grave impairment of kidney function was poorly understood. Here, for example, is a paragraph which illustrates the confusion of mind produced by the suggestion that bacteria are the cause of urethral chill.

Gosselin while adhering to the inevitable "absorption urineuse" so loved by a Frenchman inclines to the belief that the absorption of the bacteria of decomposing urine may have something to do with the deadly result as well as the carbonate of ammonia to which he ascribes a large influence. But urinary absorption will not account for the strange exceptions which are so much more numerous than even the rule.

At this very time the proof that gonorrhea is a specific disease was advanced by Neisser.

The latest attempt to explain the quality of the contagium of gonorrhoea is that of A. Neisser who in *Centralbl. of Med.*, Nov. 28, 1879, describes a peculiar micrococcus which he likens to sarcina and believes to be the cause of the disease.

Yet very probably the following note was made subsequently to the preceding one. It is to be particularly observed that no judgment is passed upon Dr. Morrow's observations.

An excellent article dealing with the question, "Is there a specific urethritis?" very ably argued and answered in the negative, appears in the *New York Medical Journal* for September 1881, p. 263, from the pen of Dr. R. A. Morrow. He quotes the experiment of Vetch who produced gonorrhoea by inoculating muco-pus from Egyptian ophthalmia—but the gonorrhoea appeared in 36 hours. Guyomar inoculated his own urethra from granular purulent ophthalmia—the results appeared on the third day, and got well after three weeks (a poor

gonorrhoea). Other similar experiments are cited.

Pauli de Laudau provoked urethritis in a man by pus from ophthalmia neonatorum, the man transmitted the disease to his wife. A. Hillier inoculated his own wife from his own urethritis produced mechanically. Otis reports a similar case.

He quotes De Luca's experiments with women showing that pus from the most varied sources injected into the urethra of a female may produce a discharge "absolutely similar to that of venereal origin." He states that "pus from urethritis applied to the eye will produce ophthalmia, pus from the conjunctiva applied to the urethra will produce urethritis." He then cites Panuus and the names of Jaeger Piringer, Van Roosbroeck Warlomont, Desmarres, Richard, to prove that the effect is the same whether pus is taken from the eye or the urethra. In Piringer's 87 cases, in 2 the pus came from the urethra of a boy 3½ years old. It is claimed in these cases that the difference in effect varies directly with the intensity of the process yielding the pus.

In the early '80's also Simon had just done his first successful nephrectomy and the interleaved pages of this volume overflow with case reports and statistics on what might be termed the elements of renal surgery.

An early method of timid nephrolithotomy is illustrated by the operation of Petersen who tapped a pyonephrotic kidney with a cannula, dilated the wound with laminaria tents and then introduced a lithotrite and crushed the stone. The patient recovered, the fistula remained open.

An early attempt at ureter catheterization in women is that of Simon who dilated the urethra sufficiently to admit the finger by which the ureteral orifice was identified and a catheter passed.

An extraordinary treatment for hydronephrosis was employed by Billroth. He first drew 1900 c.c. by tapping through the abdomen for ascites. Urea was found in the fluid so seven weeks later the refilled sac was evacuated in the same way and "24 grams of Austrian tincture of iodine with equal quantity of water injected and allowed to remain five minutes, then partly withdrawn. This injection was repeated in three months and the patient is reported as dismissed cured four months afterward."

No notes are added to the page devoted to discussion of renal tuberculosis but a great number of nephrectomies are reported, notably Barker's paper (1880) which records 29 nephrectomies with 15 deaths, the first by Wolcott of Philadelphia in 1861. Simon's case (1869), the first recovery, is of course extensively commented upon.

It took bold surgery to contemplate nephrectomy without any assurance of the presence of the opposite kidney as the many deaths amply attest. Yet by 1877 Hayes had recorded 16 successful nephrectomies, one in a child two years old.

But the grave preliminary experimental work which led Simon to his successful operation was not universally copied in those days any more than it would be today.

It is often forgotten that at the time of which we are speaking suprapubic cystotomy was absolutely taboo because of the frequency and gravity of the septicemia which complicated operations upon the bladder "above the bone." Hence the quasi-unintentional attacks upon the enlarged prostate were made by the perineum.

A. Berti broke male blade of lithotrite on a large stone in bladder of 73 year old man. He then cut (lateral) and on account of enormous size of prostate could do nothing. He then tore off the enlarged central hypertrophy and cut out stone and instrument. Patient recovered! (1880).

Bottini, of Pavia, has devised two instruments for destroying third lobes, etc., by galvano-cautery, made like a Mercier catheter and Mercier prostatome. He claims to have used it to great advantage.

C. Heine claims to have considerably reduced the size of enlarged prostates by accurate measurement by parenchymatous injection of iodine. He injected about 5 drops of tincture of iodine in water with a little over ½ grain of pot. iod. making an injection into each hypertrophied lobe. He reports experience in

six cases, all old men, and got improvement in all cases not only in reducing severity of symptoms but also in diminishing size of organ notably by actual measurement. Abscess formed only in one case and generally there was no disagreeable reaction whatsoever—some heat and smarting on urination were noticed.

Dittel has produced acute prostatitis with suppuration by the employment of Heine's method.

Outstanding growths may be cut or torn away during other operations (as for stricture or stone). Bryant has recently reported some successful cases to the *London Path. Soc., Med. Times and Gaz.*, Feb. 16, 1878. Sir W. Fergusson, *Med. Times & Gaz.*, April 16 and May 23, 1857, relates that in operating for stone he found a pedunculated prostatic overgrowth as large as a pigeon's egg which he removed (the patient died) and he refers to a case shown some time before by Sir William Lawrence at St. Bartholomew's wherein a solid whitish tumor presented, after cutting through the prostate as at stone operation, which was removed. This was doubtless one of those central tumors which shell out so easily after cutting into their surrounding tissues. (Look up.)

In contrast with such feeble attempts at operative removal of the large prostate the general results of palliative treatment by the catheter seemed worthy of consideration.

Sir H. Thompson stated at a meeting of the Royal Medical and Chirurgical Society, at which I was present in May, 1879, that he knew a gentleman aged 90 who had passed the catheter during 22 years, while a gentleman of Norwich told him that he had used the catheter upon himself 35,000 times. He (T.) had made some investigations with Dr. Messent upon the old men in Greenwich Hospital and found that while the average death rate there was 73 years, the average of those who used the catheter was 72¾ years, a very excellent showing of the harmlessness of the use of the instrument.

And now enough has been said. We may profitably close with the quotation of a few curious conditions and suggestions taken at random from various parts of the book.

Dr. W. J. Love of Wilmington, N. C., has reported a case where the same patient on two occasions at an interval of six years was relieved by spontaneous ulceration of a (urethral) calculus through the perineum. One of the stones is said to have weighed over 500 grains.

McGregor. Extraordinary case of urinary calculi, *Am. Jour. Med. Sci.*, January, 1877. Woman 63, had passed several hundred calculi in four years. Search revealed empty bladder and an number of stones (apparently) encysted. The cyst wall was cut and some stones extracted, but a stone too large to remove was felt and the operation terminated. Peritonitis. Death. Autopsy showed calculous mass in displaced kidney which rested on bladder. From this kidney there were removed on section 520 calculi of small size and one large stone weighing 51 ounces, measuring 5⅜ inches in length and 16⅝ inches in greatest circumference—apparently (not cut) uric acid.

Le Dentu presented to the Society of Surgery, Paris, a prostate containing a vast unilocular cyst as large as a small mandarin orange due to dilatation of numerous prostatic glands and subsequent disappearance of their walls. It contained a tenacious fluid and no pus and communicated with the prostatic urethra by a number of minute orifices.

William A. Hammond says, *St. Louis Courier of Med.*, May, 1880, that he has treated two cases of neuralgia of the testis, one of which was of long standing, successfully by crushing the nerves of the cord for a few minutes at a single sitting. An instrument like a lemon squeezer is recommended, the blades of which may be brought together by a screw. The cord is tightly compressed for several (5) minutes, the pressure is intermittent to allow circulation to be resumed, the pressure is again applied. The pain ceases as does also the common sensibility of the scrotum and testicle but these latter return after some days while the neuralgia remains cured.

A personal recollection of the impression made by Paul Segond's remarkably lucid presentation of the subject of prostatic abscess is the excuse for copying the summary of his statistics found in these pages.

A case of Guyon's is alluded to where prostatic abscess followed an abortive injection

used to prevent possible infection in which fear caused the patient, an old man of 50, to push the injection deeply into the urethra. Death from purulent infection followed in a few weeks.

Ambroise Pare's Abbe is referred to who after a dose of cartharides died with gangrene of the penis.

In an analysis of 77 cases of peri-prostatic suppuration the pus escaped (aided or unaided)—

64 times by the urethra
43 times by the rectum
15 times by the perineum
8 times by the ischio-rectal fossa
5 times by the groin
2 times toward the obturator foramen
1 time by the umbilicus
1 time by the great sacro-sciatic notch
1 time at the border of the false ribs
1 time by the peritoneum
1 time by diffusion, the pus reached the pre-peritoneal cavity of Retzius.

Faucon and Peter have published cases of peritonitis due to peri-prostatic suppuration.

Does it not whet your curiosity to know the history of those abscesses that discharged at the border of the false ribs or by the umbilicus?

And is it not equally stimulating to one's curiosity to encounter the following note.

Possibly peri-prostatic abscess may owe its origin to suppuration in one of the chain of lymphatic glands lying between the base of the prostate and the rectum. Lannelongue has described these glands (six in number) between the base of the bladder and the rectum. He found them enlarged and inflamed in an autopsy of a boy who died with tuberculization of the prostate, seminal vesicles, right ureter and kidneys.

DISCUSSION

Dr. Colin L. Begg: In looking over old files preparatory to discussing Dr. Keyes' paper on the beginnings of urological history in New York, it occurred to me that some details of the inception of the Association coming from one of the few remaining founder-members of the American Urological Association might possibly be of interest.

Those of you who have not had the pleasure of knowing its founder and first president, Dr. Ramon Guitéras, can have but little idea of the great privilege associating with him professionally and socially, meant. Nobly born, properly schooled, much traveled, an excellent linguist, he possessed a personality which was incontrovertible. Tall and athletic, commanding in appearance, but having withal the kindliness and simplicity of a child, he was at home alike in the courts of Europe, charity hospital ward or East-side tenement. His keen sense of humor, gracious Latin temperament, and his excellent command of English made him a prime favorite as a speaker and warranted full attendance at his lectures.

After the close of these lectures and clinics held at Post-Graduate Hospital on Tuesday, Thursday, and Saturday evenings, it was a frequent habit of "the Chief," as we called him, and us his associates to dissolve into social session and, utilizing a Continental custom, repair to some pleasing cafe or restaurant to discuss the cases of the evening. Often, because of propinquity, we would go to Sheffel Hall on 17th Street, where Wurzburger was at its best; or Lüchow's on 14th Street, where Pilsner and Münchner were prime; or the Cafe Boulevard on 9th Street, famed for its Hungarian dishes; or Moquin's on 28th Street, with its delightful French cuisine.

Thirty years ago, on the evening of day before yesterday, February 22, 1902, the Chief suggested that we try a new place on 11th Avenue in the 50's, where it was rumored there was to be had good Austrian wine. It was named the "Sieben Schwaben." There we went and discussed the advisability of founding in this country such an association as the French possessed in the "Society of Urology." After due motion and due seconding, the American Urological Association was founded, with Dr. Guitéras as its first President.

In such humble and delightful surroundings the birth of this Association, of which we are the New York Society, took place. In the early months the membership was mainly local, but gradually this was increased to such an extent that branch societies were found necessary, so that today eleven such branches are in existence in the United States and Canada; and the active and honorary members comprise many of the outstanding urologists of the world.

Dr. Edwin Beer: It is always very interesting and often amusing to reminisce. Dr. Keyes

has presented in a most entertaining manner the development of urology in New York City.

This seems to come at a particularly appropriate time, when the French are celebrating the centenary of Félix Guyon, whom they acclaim as the "Father of Urology." Many of us are greatly interested in Guyon. We know his work; we know his many contributions to this branch of surgery. Many of us would have been disappointed if Guyon had been substituted for Nélaton, surgeon to Napoleon III during the Franco-Prussian War (as Legueu tells us very nearly happened). If Guyon had been recognized as the proper man to take care of Napoleon's bladder stone, the battle of Sedan, he claims, would have been a French victory and the World War never fought, no Alsace-Lorraine question—a very fortunate thing for the rest of the world. Napoleon III could not ride horseback with a stone in his bladder. The story goes that the army was defeated by the Prussians and Napoleon taken prisoner because of the slow progress of his horse and victoria. If the "Father of Urology" had had his chance, the stone would have been taken care of and no World War would have taken place. This demonstrates the importance of modern urology. Yet it is interesting to note that a man as keen as Guyon could fail to recognize prostatectomy as a feasible procedure; that he believed that anyone who did it could be considered a murderer (as he probably would have been in those days). He came out flat-footedly against it.

Another remarkable mistake of his was in connection with renal tuberculosis. He said it was a disease which affected the whole urinary tract, genital as well as kidneys and it took many years before James Israel of Berlin was able to persuade the medical and surgical profession that nephrectomy would cure it. And we all know it has provided such a cure to 65–80 per cent of those suffering from it.

Although I have not been so fortunate as Dr. Keyes in his heritage of the Van Buren, Gouley and Senior Keyes traditions, I can very well remember that master surgeon, Charles McBurney, and his lateral approach to the bladder. It was in those days a most mysterious procedure to see him go in through the lateral perineal route and in less than five minutes deliver a stone by forceps. It seemed in a class with necromancy.

Dr. Keyes spoke of the early use of iodine in the prostate. In the German literature mention is made even now of iodine introduced into the prostate in cases of hypertrophy. It is used in a great many clinics, and highly recommended as Pregl solution.

Tonight's reminiscences recall to me one of the early surgeons whom I happened to have come in contact with and who considered himself a urologist, Dr. Fluhrer. In his day he ran a service in two or three hospitals, including Mount Sinai, as a genitourinary specialist. It was most amusing to see his work on the urethra. When he got above the prostate, he was absolutely lost; but in the urethra, as far as instrumentation was concerned I do not think there ever has been anyone who was quite so meticulous in whittling down whalebone bougies, and in twisting and cutting them to suit his purposes. I remember well a ward where he was trying to whittle down one of these bougies. He would stop work if a door was slammed or any noise made until there was absolute silence as he worked. He was a most determined man, so much so that he insisted upon being operated upon for appendicitis, although he had a ureter stone. The ureter stone was palpated at the time of operation, and he passed it a week later.

One day, in the operating room, he passed a sound. This was in precystoscopy times, as only the general surgeon, strange to say, was doing cystoscopy then. He encountered a click. He said, "Ah, a stone," and tried again and again to repeat that click, until the anesthetist advised him that his patient was very ill indeed. He had been under anesthesia for forty-five minutes or more during this procedure. Then Dr. Fluhrer decided to go in from above. Instead of finding a stone he found an enormous encrustated carcinoma. The patient died of ether pneumonia.

In the early days every surgeon had his own urethrotome. Apparently all efforts were directed against the urethra. There was Otis' urethrotome, Maissoneuve's, Gerster's, Lange's, etc. Fortunately few of these instruments are in vogue now, all having been quite properly junked or given to museums.

That early note Dr. Keyes read about acid urine remaining sweet and clear was very interesting. There is no doubt that most of us, in our hurry nowadays, have not profited by some of the experience of those who have gone

before us. Acid urine will remain absolutely uncontaminated for many months (six or seven); and our attention is often directed to the fact that it remains not only hyperacid but is full of uric acid crystals. It brings up again the old question of uric acid shower colics. I have mentioned this repeatedly before this and other societies, recently. When Dr. Braasch was here he told me that he made a practice now of letting urine stand for several days (as did our predecessors) in his search for uric acid crystals and in an attempt to correlate his findings and the symptoms of colic. The older practitioners regularly proceeded in this way, and the moderns have not followed in their footsteps.

Dr. J. Sturdivant Read: The subject of Dr. Keyes' paper of this evening suggested to me to investigate what was happening in my own hospital in the early '60's. The Medical Department of Long Island College Hospital was functioning well by 1860, and constant references show that the surgeons in Brooklyn at that time performed the genito-urinary surgery of that day.

The first formally appointed professor of surgery and lecturer on venereal diseases seems to have been in 1873, Dr. George K. Smith; from 1882 to 1884, Dr. George H. Atkinson; from 1885 to 1895, Dr. Henry Walter Rand occupied the chair. In his own handwriting I find the record, "lecturer of diseases of the genito-urinary organs, 1885, and clinical professor of diseases of the genito-urinary organs from 1886 to 1895." Dr. Henry Morton succeeded Rand. It was due to Dr. Morton that the full importance of urology as a separate branch was recognized and established in our institution. His contributions are too well known to all of us to need any mention, and I only wish to speak of the earlier men, Dr. Smith and Dr. Rand.

Along with Otis' belief in cutting strictures in the anterior urethra (which by the way is still a good procedure), Smith had an equally confirmed faith in meatotomy. He believed it would cure all the ills that flesh is heir to. He did meatotomies for everything; and incidentally probably cured some things which could not be handled in any other way. I was talking with two of his contemporaries recently about Smith, men who knew him well, and they told me the following stories:

It seems he was called to see a desperate case of pneumonia one day. So sold was he on the idea of meatotomy that he immediately prescribed this procedure, after which he remarked, "See, he breathes better and more vigorously than before."

The other story was probably the highlight of his career. Smith used to drive around Brooklyn behind an old white horse. One day it balked in front of the hospital and refused to move. He climbed out of the carriage, did a meatotomy on the horse, and henceforth proceeded to drive all over Brooklyn without difficulty.

Lest we seem to speak lightly of a very able gentleman, I append a short biography:

Dr. George K. Smith was born in Broome County, N. Y., in 1827 and died in 1895 at the home of his nephew Dr. Frederick W. Smith of Syracuse. A graduate of the University of New York, he received the Mott medal for the best dissection in anatomy, and became an interne at the Brooklyn City Hospital in 1859; demonstrator in anatomy at Long Island College Hospital in 1860; in 1862 Hospital Inspector at Washington, D. C.; and acting assistant surgeon until the end of the war. In 1866 he visited London, Paris, and Edinburgh. While in London he secured the friendly recognition of Sir James Y. Simpson in consequence of a paper "Insertion of the Capsular Ligament of the Hip Joint, etc."

He returned to Brooklyn in 1870, and was appointed adjunct professor of surgery in the Long Island College Hospital and the next year also adjunct professor of anatomy. From 1873 to 1881 he is marked as holding the above titles and also that of lecturer on venereal diseases. He was professionally prominent in Brooklyn from 1860 to about 1890, and the good-natured stories told about his enthusiasm for the procedure of meatotomy reflected only the good will of his contemporaries, one of whom, Dr. George Everson, told me that he had seen him do many perineal incisions and remove middle lobes of the prostate; that he preferred to do median cystotomies for stone, saying that the crushing operations were no good; that once he had seen him diagnose a large kidney by palpation, make a loin incision, tie the pedicle en masse, pack the wound, "all in the patient's home on Columbia Street, and the patient got well." It turned out to be a polycystic kidney.

BOOK REVIEWS

DIE ELEKTROCHIRURGIE. By Prof. Dr. Franz Keysser, Direktor Des Vinzenzkrankenhauses, Berlin. Leipzig, Fischers Medizinische Buchhandlung, 1932.

Electrosurgery within the past ten years has advanced by leaps and bounds into practically every surgical speciality. The world has been looking for a recent, scientific treatise of the subject, particularly one from Europe where electrosurgery had its beginning several decades ago. It was, therefore, timely for Keysser to write his excellent work. Any surgeon, in whatever speciality, would do well to study Keysser before taking up electrosurgery.

After outlining the history of the development of electrosurgery and accurately describing the underlying physical principles and the apparatuses used, he describes the technique in detail and carefully discusses the biophysical effects. He then takes up the diseases treated, one by one, illustrating the results with especially clear pictures. Keysser's results are apparently remarkable and the publishers have reproduced the illustrations in a most commendable way. Not only has he shown the results in the eradication of tumors, but his reconstruction work is of a high type.

NEOPLASMS OF DOMESTICATED ANIMALS. Mayo Clinic Monographs. By William H. Feldman, D.V.M., M.D. Foreword by Charles H. Mayo, M.D. 410 pp., 193 illus., Phila., W. B. Saunders Co., 1932.

This book, the latest of the Mayo Clinic Monographs, should be of interest to everyone doing any work on Tumors. It is the most complete study on animal neoplasms known to the reviewer and is written with that care and concise thoroughness which we have come to expect in the books emanating from this Clinic.

MODERN GENERAL ANESTHESIA, A Practical Handbook. By James G. Poe, M.D. 231 pp., 12 illus. and 2 charts. Phila., F. A. Davis Co., 1932.

This is an elementary book of 231 pages and attempts to cover the entire subject of general and local anesthesia. It is possible that this book covers just what the author's students want but, for general usage, it is felt that there are much more complete and practical works available.

CONQUERING ARTHRITIS. By H. M. Margolis, M.D. 192 pp. N. Y., Macmillan Co., 1931.

The physician handling the chronic arthritic will do well to recommend the reading of this book which is written for the patient and which, if properly read by the layman, will save the doctor much time spent in unnecessary and usually misunderstood explanations. The author has a faculty of getting his facts across in plain language that should be easily understood by the average patient.

MANUAL FOR THE JEWISH DIABETIC. By William S. Collens, B.S., M.D. Foreword by Henry Joachim, M.D. 138 pp. N. Y., Bloch Publ. Co., 1931.

Since diabetes has been called "the Jewish disease" it is interesting to know that this volume is said to be the first manual on diabetic diets which takes into account the Jewish dietary laws. The purpose for which this book was written has been well accomplished.

ATLAS DE RADIOGRAPHIE OSSEUSE. Vol. I. (The Normal Skeleton.) By G. Haret and A. Dariaux, Electroradiologists of the Hospitals of Paris, and Jean Quenu, Assistant Professor to the Faculty of Medicine, Surgeon of the Hospitals of Paris, with the collaboration of H. P. Chatellier, Oto-Rhino-Laryngologist of the Hospitals. Ed. 2, revised and greatly enlarged. Preface by Prof. Pierre Duval. Paris, Masson et Cie, 1932.

The medical profession more and more appreciates the need of atlases of radiological anatomy, the first edition of this beautiful work published in 1927 having been exhausted within a short time. Profiting by the reception given the first edition, the authors have added numerous illustrations, others of medi-

ocre value have been replaced by better ones, and some which seemed superfluous have been entirely omitted. Special attention has been given to the choice of illustrations at various ages to permit the student to follow the development of the points of ossification, and their final complete development. A revised chapter discusses the radiography of the fetus in utero, and an entirely new chapter deals with supernumerary bones, familiarity with which is so necessary for the differential diagnosis of certain fractures.

The bookmanship of the work is much improved over the first edition, the reproduction of the roentgenograms leaving little to be desired. The large size of the pages make it possible to reproduce nearly all the films without reduction in size.

Two other volumes on bones are in preparation, one dealing with fractures and another with diseases of bone.

Hypertension and Nephritis. By Arthur M. Fishberg, M.D. 619 pp. 38 eng. and 1 col. pl. Ed. 2, thoroughly revised and enlarged. Phila., Lea & Febiger, 1931.

The second edition, in a space of only a few years, of a monograph on Hypertension and Nephritis is in itself sufficient proof of the value of this work. In a little over 600 pages, this book covers the ground indicated in its title thoroughly and completely, showing evidence of much original work. The book also contains a splendid survey of all the work that has been done in these lines. The bibliographies are well selected.

Manual of Bacteriology. By Robert Muir, M.D.,Sc.D., LL.D., F.R.S. and the late James Ritchie, M.D., F.R.C.P. (Ed). Revised by Carl H. Browning, M.D., D.P.H., F.R.S. and Thomas J. Mackie, M.D., D.P.H. Ed. 9. 866 pp., 212 illus. and 6 col. pl. Humphrey Milford, Oxford Univ. Press, 1932.

The ninth edition of this classic is like a visit from a friend of our youth. Thoroughly practical, condensed and yet complete, this little manual is one of the best one volume works on Bacteriology available in the English language.

Schmerzverhütung Zwölf Vorlesungen. By Dr. Fritz Starlinger. Wien, Julius Springer, 1931, 105 pp.

In twelve short lectures comprising in all 105 pages, the entire subject of Anesthesia is given in short but comprehensive reviews. Much philosophical discussion is included and indications and contraindications for the various drugs are pointed out. The author is conversant with the literature and seems to have much practical experience. It is a splendid introduction to larger works on Anesthesia.

Die Schleimhaut des Verdauungskanals im Röntgenbild: Eine Normale und Pathologische Röntgenanatomie der Innenwand des Verdauungskanals. By Henri Chaoul and Albert Adam. Berl., Urban & Schwarzenberg, 1931.

This is a splendid book, well written, and beautifully illustrated; the reproductions of roentgenograms are excellent. The technique followed is very much like that of Berg and Forssell. With this method only a little barium is given and every effort is made to show detail in the folds of mucous membrane of the stomach and bowel. Special forms of compression capsules are used. The films obtained are beautiful and often show very clearly lesions which would not appear on ordinary plates made when the stomach is full.

In America many roentgenologists obtained very much the same results by giving the patient only a few swallows of barium and then palpating the stomach carefully while the patient is back of the fluoroscopic screen.

There are excellent chapters on the historical development of the new method of showing the mucosal folds, on the appearance of the folds in the normal esophagus, stomach, and bowel and on the change that takes place in these folds during the progress of peristalsis. In the second part of the book the writers describe changes which take place in the folds in the presence of various diseases and after the performance of various operations. There is an excellent bibliography containing many hundreds of titles. Altogether the book is one that every roentgenologist and clinician would like to have in his library.

PERIPHERAL NERVE INJURIES

LEWIS J. POLLOCK, M.D., AND LOYAL DAVIS, M.D.

SIXTH INSTALLMENT

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Chapter XXI

TREATMENT OF IRREPARABLE NERVE INJURIES

There is a certain group of nerve injuries to which the term "irreparable" may be given. This group includes those cases in which the nerve ends have been sutured but in which recovery of muscle function fails to occur and those nerve injuries which are so extensive that end-to-end suture cannot be obtained. It is a well-known fact that the percentage of functional recovery after nerve suture is much higher following civil than war injuries. In such instances it becomes necessary to resort to various supplementary procedures which may afford some degree of function in the involved extremity.

These alternative surgical methods may be classed in general under three heads: (1) tendon transplantation, (2) neurotization of the paralyzed muscles and (3) immobilization of joints. None of these supplementary operations should be employed until it is established definitely that the possibility of nerve regeneration is precluded.

Tendon Transplantation

While the principles which govern tendon transplantations in the upper and lower extremities are the same, it must not be forgotten that in the upper extremity mobility is the chief aim to be accomplished and in the lower extremity fixation for stable weight bearing is essential. To obtain mobility it is requisite that the joint upon which the transplanted tendon is to act should not be restricted in its movements. A fixed or deformed joint cannot be expected to respond to its fullest function even though the tendon transplantation is perfect. Before a tendon is selected for transplantation the ability of its muscle belly to perform the task required of it must be determined carefully. One should not expect a normally small weak muscle to perform the action of a stronger muscle though

one may reasonably expect it to hypertrophy to a degree comparable to its added burden. One should also have a definite knowledge of the synergistic action of muscles. It is a physiological law that each contracting muscle group has its antagonistic muscles which relax simultaneously during the movement. On the other hand, muscles which may appear to be anatomically antagonistic may contract simultaneously to fix a joint during all or part of the movement and thus act physiologically in a supplementary manner. The choice of a tendon to be transplanted may also be made less difficult by a knowledge of those muscles which normally supplement or take over the action of a paralyzed muscle, at times to such an extent that the determination of individual muscle paralysis may be difficult to determine. Attention has already been called to these supplementary muscle movements.

Technically there are several important factors which must be kept in mind. First of all, there should be a direct pull from the point of origin to the proposed point of insertion. Angulation, of necessity, will reduce the efficiency of the transplanted tendon. Often long incisions and extensive mobilization of the tendon and muscle belly may be necessary to obtain this end. Further, the transplanted tendon should be placed beneath other muscle bodies or the fatty superficial tissue rather than beneath the skin where adhesions may easily curtail the functional result. Perhaps the most difficult step of all in tendon transplantation is to determine at what tension the tendon should be sutured to give the desired end result. Immediately after severance of the tendon, its muscle fibers contract and its length shortens. One should never stretch the muscle to the point where its inherent tone may be destroyed. The joint to which the tendon is to be sutured should be flexed or extended to the degree to which function in the joint is desired. The tendon should then be attached with the joint in that position. Under such circumstances when the muscle fibers relax, there will be a residual tension comparable to that in the muscle before it was transplanted.

Before transplantation a splint should be prepared to hold the joint in the desired position. This should be applied immediately so that the suture line may be protected during the period required for firm healing. Mason and Shearon have shown that the line of union should be healed sufficiently by the end of two weeks so that passive movements may be instituted without fear of avulsion. The institution and performance of massage and active and passive movements should then be started to avoid restriction of joint movements by immobilization and to stretch any adhesions which may have a tendency to form. These physical therapy procedures should be undertaken and controlled under the same conditions as have been outlined in the chapter devoted to Postoperative Treatment. The splint should be worn the greater part of the time until the patient is able to grasp the re-educational movement and until the tendon is able to bear its new functional demand without fatigue.

The use of tendon transplants may be better explained by specific illustrations for individual irreparable nerve lesions.

Radial Nerve Lesions: The wrist and finger drop deformity of an irreparable radial nerve injury lends itself most satisfactorily to repair by tendon transplantation. There have been several operative procedures devised by Sir Robert Jones, Murphy and others to correct the functional disability which accompanies a wrist drop. The essential steps in this procedure are (1) the transplantation of the pronator radii teres into the long and short extensor carpi radialis to produce dorsal flexion of the wrist and (2) the transplantation of the extensor carpi ulnaris tendon into the flexor carpi ulnaris to prevent deviation of the hand to the radial side.

To accomplish these procedures an incision is made along the radial side of the forearm in its middle third. The plane of cleavage between the brachioradialis and the extensors of the wrist is dissected down to the radius. The insertion of the pronator teres is then divided from the radius and with the wrist in extension its tendon is slipped through a slit in

the extensor carpi radialis longior and brevior tendons and anchored. To prevent radial deviation in extension the tendon of the extensor carpi ulnaris is divided and transplanted into

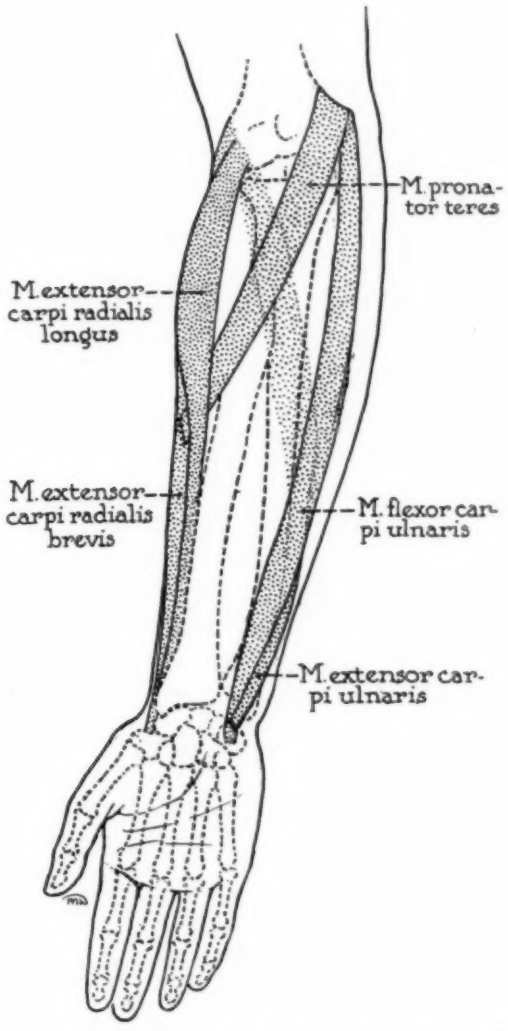
M. pronator teres
M. extensor carpi radialis longus
M. extensor carpi radialis brevis
M. flexor carpi ulnaris
M. extensor carpi ulnaris

FIG. 134. Transplantation of tendons for repair of wrist drop in radial nerve paralysis.

that of the flexor carpi ulnaris (Fig. 134).

For the restoration of extension of the fingers and thumb it is necessary to transplant the flexor carpi ulnaris tendon into the extensor tendons of the third, fourth and fifth digits and

the flexor carpi radialis into the extensor ossis metacarpi pollicis, extensor pollicis longus and brevis and into the extensor tendons of the index finger. The palmaris longus tendon may be used to transplant into the long extensor tendon of the thumb. To obtain these transplants it is necessary to make a long incision on the ventroradial aspect of the forearm which begins at the insertion of the flexor carpi radialis tendon and extends to the middle of the forearm. This tendon should be well mobilized but care must be taken to protect the radial artery. A similar incision on the ventro-ulnar side of the forearm will be necessary to effect a similar immobilization of the flexor carpi ulnaris tendon. A third incision should be placed on the mid-dorsal surface of the forearm from the wrist joint to the middle of the forearm. The superficial tissues should be undermined carefully so that the ventroradial and ventro-ulnar incisions connect. This procedure will expose all of the extensor tendons which are to be utilized. The divided flexor carpi ulnaris tendon should then be brought to the dorsum of the wrist and its end passed through slits made in the extensor tendons of the middle, ring and little fingers and there anchored with these fingers in extension. Likewise, the end of the flexor carpi radialis tendon is passed through slits made in the long extensor of the thumb and both extensors of the index finger and anchored with the thumb in complete extension and abduction and the index finger in full extension. After the wounds are carefully closed a splint should be applied to keep the wrist, thumb and fingers in extension (Fig. 135).

Stoffel has devised a fascial transplant operation to correct the pendulous hand and fingers in this group of cases. A fascial strip is attached to the radius and ulna and to the first and second metacarpal bones on the radial side of the extensor tendons and to the fifth metacarpal bone on the ulnar side of the extensor tendons. The wrist is held in marked dorsiflexion during this attachment. If it is desired to raise the fingers also the distal end of the fascia is cut into five points which are sutured to the proximal phalanges. It should be pointed

out that in certain cases so operated upon the fascia has stretched and the deformity has recurred.

MEDIAN NERVE LESIONS: The loss of sensation in the

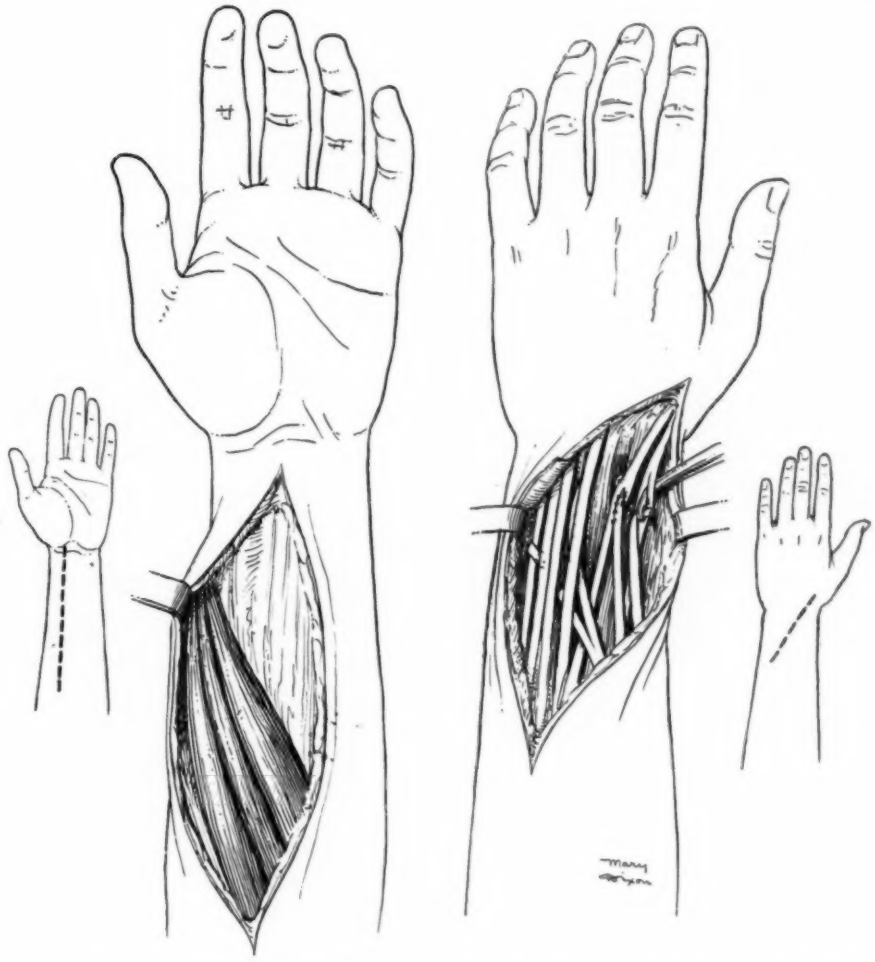

FIG. 135. Transplantation of tendons to paralyzed extensors of fingers and thumb in radial nerve paralysis.

index and middle fingers which results from a median nerve lesion makes the attempts to compensate for an irreparable lesion doubly difficult. Though the results are not particularly encouraging one may have recourse to an autogenous nerve graft. Or, one may attempt to unite the central end of the superficial sensory branch of the radial nerve to the distal end

of the median. It must be remembered that even though regeneration may occur under such circumstances, tactile sensation which is most important may still be lacking. In the presence of a combined median and ulnar lesion it may be possible to anastomose the central end of the ulnar and the distal end of the median. While this sacrifices the ulnar distribution the success of this procedure may afford more ultimate function than would otherwise be possible. These facts only emphasize how important it is to use every method at one's command to obtain a satisfactory end-to-end median nerve suture.

Since the ulnar half of the flexor digitorum profundus provides flexion in the fourth, fifth and occasionally the middle finger it is necessary only to provide flexion to the index finger and flexion and opposition to the thumb. To accomplish these results the flexor tendons may be anastomosed to the flexor carpi ulnaris. Ney, however, has obtained more satisfactory results by anastomosis of the tendon of the extensor ossis metacarpi pollicis to the flexor pollicis longus and then transplanting the extensor carpi radialis into the flexor tendons of the index finger. If the thumb has become displaced laterally so that its position of function cannot be maintained it may be necessary to perform an arthrodesis and fix it into a position of opposition and abduction. Without the thumb in this position the greatest functional restoration of the hand cannot be obtained. Ney has devised an operation for restoration of the opponens function of the thumb which he states duplicates this action and at the same time allows complete extension. The procedure consists in bringing the short extensor tendon of the thumb through a tunnel under the fat of the superficial fascia. It is then passed beneath the annular ligament to the wrist where it is anastomosed to the palmaris longus tendon.

Ulnar Nerve Lesions: The failure of return of function in the intrinsic muscles of the hand supplied by the ulnar nerve produces a particularly disabling deformity. A marked degree of atrophy occurs in these highly specialized intrinsic muscles

in a comparatively short time. Paralysis of the flexor carpi ulnaris and the ulnar half of the flexor digitorum profundus muscle may be compensated for by tendon anastomosis to the unparalyzed portion of the latter muscle which is supplied by the median nerve. Restoration of the function lost by paralysis of the small hand muscles will be discussed in the following paragraphs which deal with irreparable combined lesions of the median and ulnar nerves.

MEDIAN AND ULNAR NERVE LESIONS: Irreparable lesions of the median and ulnar nerves combined result in a deformity which renders the hand useless unless some degree of flexion of the fingers can be obtained by tendon transplantation. Occasionally following a suture of these nerves there may be a restoration of function in the flexors of the wrist and fingers, and in the pronators, but there is a residual disability due to atrophy of the small hand muscles. Under such circumstances the loss of the opponens function of the thumb, inability to flex the metacarpophalangeal joints and loss of extension of the interphalangeal joints and hyperextension of the metacarpophalangeal joints reduces the function of the hand considerably.

To restore the opponens action to the thumb the palmaris longus tendon may be sutured to the short extensor tendon of the thumb. If the palmaris longus tendon is absent the flexor carpi radialis may be utilized. An incision is made in the midline over the course of the palmaris longus tendon from the base of the palm below the annular ligament upward for about 3 inches. The palmaris longus tendon is divided and mobilized. The annular ligament is divided longitudinally for about an inch and a circular opening is made through it near its distal border. Another incision is made over the dorsal surface of the thumb from a point just distal to the metacarpophalangeal joint to the radiocarpal articulation. This incision should bisect the anatomical snuff box. The sheath of the short extensor tendon of the thumb is opened and the tendon is isolated. It is then divided opposite the proximal end of the incision. The free end of the tendon, which is still attached to the

base of the proximal phalanx of the thumb is then passed beneath the superficial tissues to the circular opening in the annular ligament. It is passed through this and sutured to

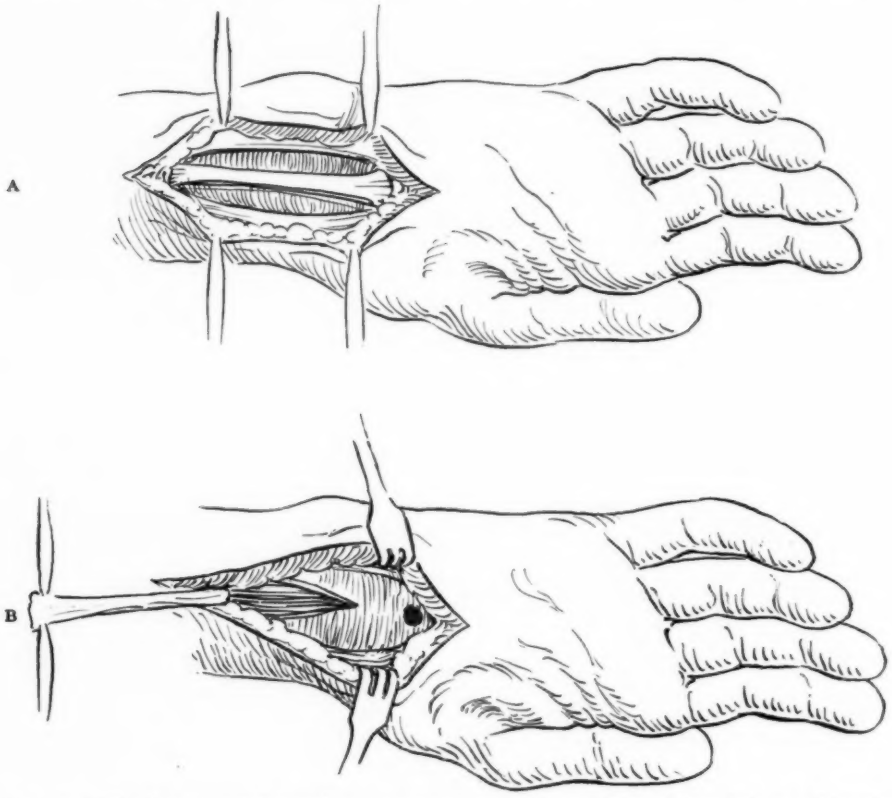

FIG. 136. Tendon transplantation to restore opposing action of thumb in median-ulnar nerve paralysis. (After Ney.)

A. Exposure of palmaris longus tendon.

B. Division of palmaris longus. Opening in palmar fascia at upper end of annular ligament.

the palmaris longus. The thumb should lie across the palm in an opposed and abducted position following this operation. Inasmuch as contraction of the palmaris longus tendon always accompanies prehension of the thumb the action afforded by this transplant is synergistic (Fig. 136).

Stiles has devised an operation to restore flexion of the metacarpophalangeal and extension of the interphalangeal joints. The operation consists in suturing the insertions of the

flexor digitorum sublimis tendons to the extensor digitorum communis at a point distal to the metacarpophalangeal joints. Through a mid-dorsal incision the common extensor tendons

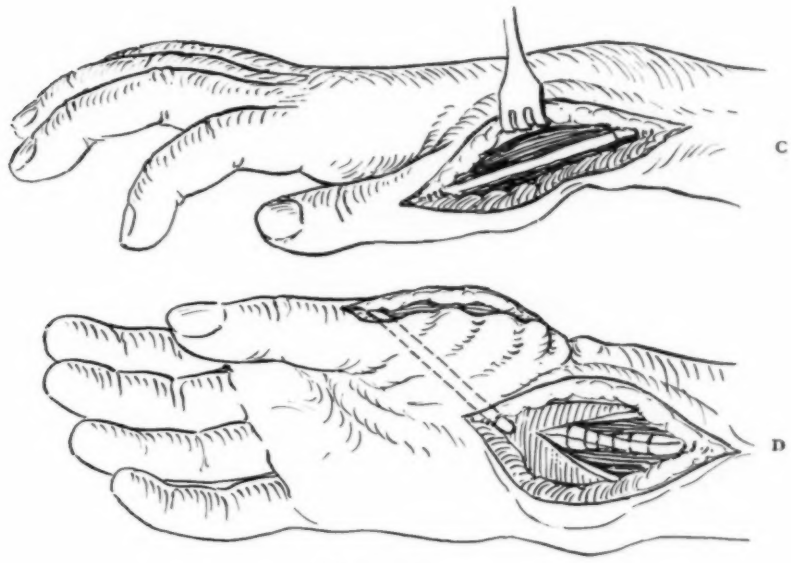

FIG. 136.

C. Exposure of short extensor of thumb.

D. Passage of divided short extensor tendon through a subcutaneous tunnel in thenar eminence and through opening in palmar fascia. It is then anastomosed to palmar longus tendon. This holds thumb in opponens position.

are exposed and the insertions of the interossei and lumbricales muscles into its lateral aspect are freed. By separate incisions along the flexor surface of each finger the flexor tendons are exposed from the palmar crease to the distal interphalangeal joint. The tendon sheath is opened by a small lateral incision opposite the middle interphalangeal joint where the sublimis tendons divide to allow the deep tendon to pass distally. The insertions of the sublimis tendons are divided. Another incision is made through the flexor tendon sheath opposite the metacarpophalangeal joint and the ends of the sublimis tendons are pulled out of the sheath. The tendon sheath incisions must be made laterally and not directly beneath the skin incision. Further, the small attachments of the profundus tendons

opposite each phalanx must not be disturbed. Each half of the sublimis tendon should be passed around the digit to the dorsal incision and then should be sutured through the extensor tendon at the point where it receives the lumbricales and interossei muscle insertions. The tendons should be sutured with the metacarpophalangeal joints in flexion and the interphalangeal joints in extension. After closure of the incisions the fingers should be fixed in that position.

In the event that the lesions of the median and ulnar nerves are high so that the flexor tendons to the wrist and fingers are also paralyzed, an attempt may be made to supply some degree of flexion to the fingers by transplantation of the extensor tendons. By a long incision from the base of the thumb over the dorsal aspect of the forearm to its upper third the extensor radialis longior tendon is freed and divided at its insertion into the second metacarpal bone. The tendon is divided into two slips, one of which is sutured into the flexor tendons of the index finger and the other into the tendons of the middle finger. In a like manner the tendon of the brachioradialis is sutured to the flexor tendons of the ring and fifth fingers. The tendon of the extensor ossis metacarpi pollicis is divided at its insertion and sutured to the long flexor tendon of the thumb. The incisions are closed and the fingers are held in flexion, the position in which the transplants are sutured.

Sciatic Nerve Lesions: The major disabling defect which follows sciatic nerve lesions is the loss of stability of the foot. The loss of motor function which follows a lesion of the tibial portion of the sciatic is more disabling than that which accompanies a lesion of the peroneal nerve. If the dorsal flexion of the foot is permanently lost, arthrodesis of the ankle joint or the operation of tendon slinging may be used to correct the drop foot. Of these two procedures the latter is more satisfactory because arthrodesis cannot stabilize the anterior half of the foot. No muscle or tendon groups are available to supplement the movements of the anterolateral group of muscles which are supplied by the peroneal nerve.

Tendon slinging consists in passing the upper parts of the tendons of the tibialis anticus and peroneus longus through a hole in the shaft of the tibia where they are sutured. The

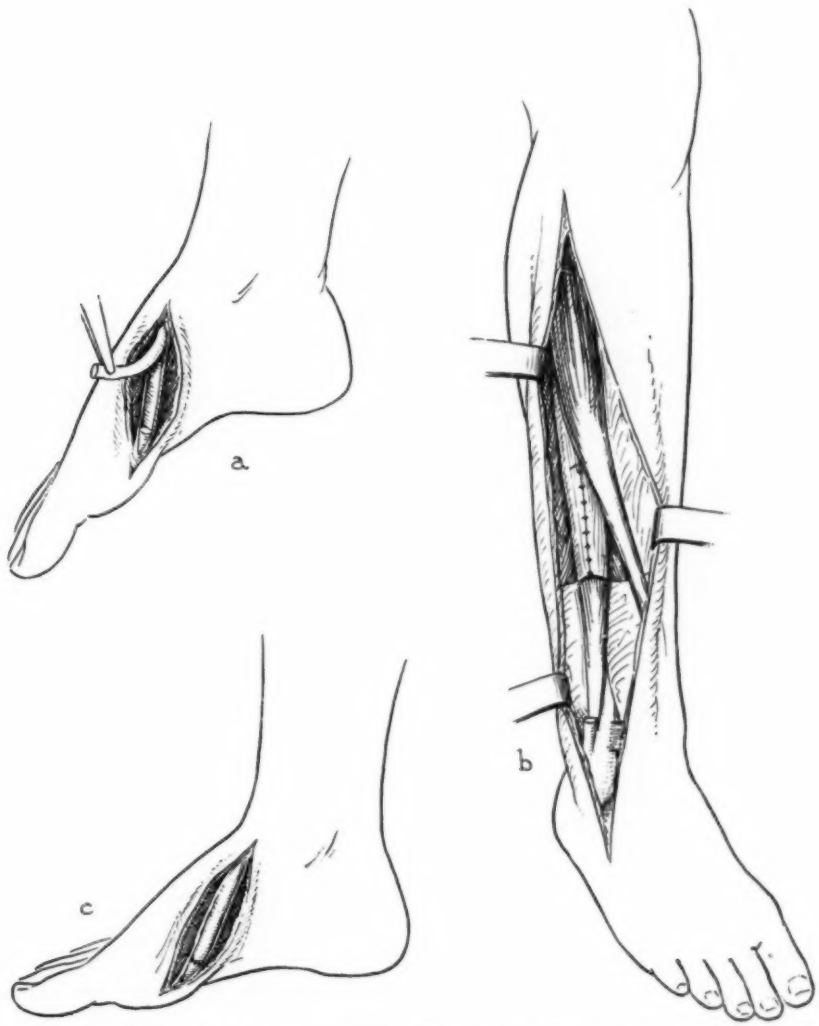

FIG. 137. Tendon slinging to overcome foot drop in peroneal nerve paralysis.

peroneus brevis may also be used in this procedure. The extensor tendons of the toes are used in a like manner to suspend the anterior half of the foot (Fig. 137).

Neurotization of Muscles

It has been shown by experimental and clinical work that a muscle may be innervated directly by the implantation of a nerve into the muscle and that motor end plates will develop on the muscle fibers. This procedure may be found useful if a nerve branch to a given muscle has been severed near its entrance into the muscle and it can be freed and implanted at a higher level.

In 1908, Hacker implanted the central end of the spinal accessory nerve and a motor branch from the cervical plexus into the trapezius muscle. Later he obtained a contraction of the trapezius by stimulation of the nerves. In 1917, Kölliker obtained a response after implantation of the entire median nerve into the paralyzed biceps muscle in two cases. Forrester performed direct implantation of the median, peroneal and musculocutaneous nerves in six cases with complete return of function in four of them, partial return in one and failure in the remaining case. Erlacher, in 1914, implanted the median nerve into the biceps muscle of monkeys after first sectioning the musculocutaneous nerve. He obtained not only contraction of the muscle upon stimulation but was able to demonstrate histologically normal neuromuscular connections. In the same year Heineke implanted the peroneal nerve of the rabbit into the gastrocnemius muscle after severance of the tibial. He obtained regeneration within twenty-eight days. Steindler, in 1916, attempted to corroborate the experimental results of Erlacher and Heineke. He sectioned the femoral in dogs and implanted the tibial into the vastus externus muscle. After ten weeks Steindler was able to produce contractions in the muscle by stimulation of the implanted nerve with a current which was weak enough to avoid retrograde stimulation of the flexor muscles. It was observed grossly that the muscle fibers directly about the implanted nerve were redder in color than those at a distance. In spite of precautions taken to avoid its occurrence Steindler found in some instances that a few fine

regenerated branches from the severed femoral nerve entered the muscle. These were in the minority so that they played but a small part in the neurotization of the muscle. In none of his experiments was Steindler able to show that the muscle fibers became hyper-neurotized.

In 1916, Hoessly implanted the branch of the spinal accessory which supplies the sternomastoid muscle into the laryngeal muscles of dogs after first sectioning the recurrent laryngeal nerve. His experimental results were so successful that he proposed the operation for human cases. Elsberg, in 1917, found that if two nerves were implanted into a paralyzed muscle of a rabbit and if one of the nerves was the severed nerve which normally supplied the muscle, this nerve alone would regenerate and establish motor end plates.

The successful clinical application of neurotization may depend upon the length of time paralysis has existed before a nerve is implanted. In other words, the anatomical change in the muscle fibers may be such as to obviate any possibility of regeneration. However, Steindler calls attention to the fact that in many instances a large amount of apparently healthy muscle fibers are found in muscles which have been paralyzed for several years.

The technical procedure of nerve implantation is not difficult. The central end of the nerve should be freed and sectioned across until normal appearing funiculi are visible. Two fine silk sutures are passed through the epineurium about 2 mm. from its end. In selecting the point on the muscle into which the implantation is to be made the action of the muscle and its movements in changes of the position of the extremity must be kept in mind so that undue tension on the nerve will not be exerted. A small opening is made in the muscle parallel to its fibers. Complete hemostasis of the nerve end and of the muscle should be obtained. The nerve should be sutured into the muscle with the epineural sutures already placed so that the nerve end is directed toward the muscle's point of insertion. The muscle incision should be closed over the implanted nerve.

If necessary other epineural sutures may be used to avoid angulation of the nerve (Fig. 138).

An alternative method for the neurotization of paralyzed

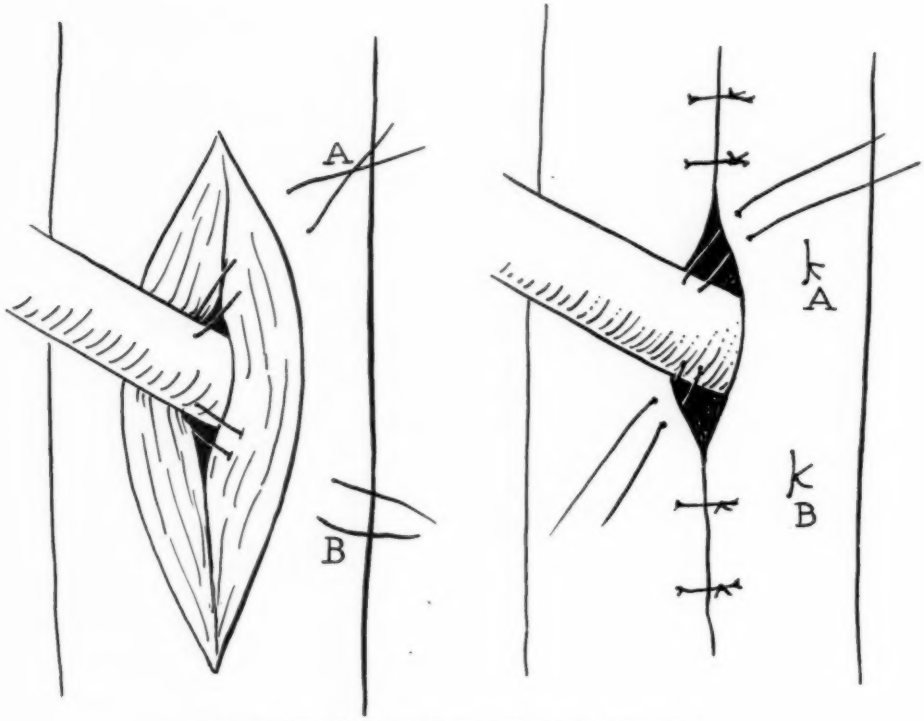

FIG. 138. Technique of neurotization of muscles.

muscles was first suggested by Gersuny, in 1906. His method consists in the transplantation of a muscle flap with its nerve supply intact into the paralyzed muscle. The normal nerve fibers should then grow out from the transplanted muscle flap. Gersuny transplanted a flap from the trapezius into the paralyzed deltoid and stated that he obtained a good functional result. Erlacher also reported successful experimental and clinical results by this method and emphasized the importance of using a broad base for the flap so as to maintain its nerve supply. Nutt, in 1917, reported 20 cases of muscle flap transplantations in patients with infantile paralysis. Thirteen of these were failures; 2 showed good and 4 fair recovery. It is the

consensus of opinion that neurotization by the implantation of the nerve itself is superior to that of muscle implantation.

Immobilization of Joints

In old neglected cases of nerve injuries which may prove finally to be irreparable, the only procedure which may afford even slight functional improvement is immobilization of the joint in the position of greatest function. In the lower extremity both the knee and ankle joints may be immobilized with some degree of functional improvement. In the upper extremity the wrist and elbow less frequently call for this operation.

Surgical fixation of the ankle joint to afford a firm weight bearing surface in patients with a foot drop has been described previously in the discussion of irreparable lesions of the tibial nerve. It should be emphasized again that arthrodesis of the ankle joint does not stabilize the anterior half of the foot.

In irreparable defects of the radial nerve which have not been treated with massage and physical therapy so that tendon transplantations are valueless it may be a distinct advantage to fix the wrist joint in extension. This position approximates the position of function of the hand and one needs only to attempt to flex the fingers with the wrist in flexion to realize how much function this adds to the hand. In a like manner the elbow joint may be ankylosed in semiflexion with the forearm midway between pronation and supination to add materially to the functional improvement of the upper extremity.

Chapter XXII

THE RADIAL NERVE

Of all the peripheral nerves the radial is the most commonly injured in civil life. During the war radial nerve injuries constituted almost one-fourth of all the nerve injuries. In civil life it is commonly involved because of its length and winding course about the humerus. It is exposed to wounds and to other injury from external sources. Dislocation of the shoulder and fractures of the humerus may produce an immediate injury to the nerve. Callus formation about a fracture, traumatic aneurysms and compression by a bandage, cast or splint may subsequently produce an involvement of the nerve. It may become involved in a bony newgrowth or it may be affected by tuberculosis or syphilis of the bone. It may be disregarded by the surgeon and injured during operations upon the upper extremity. It is common to have a radial nerve paralysis follow continued pressure upon the arm, such as occurs particularly in a drunken sleep. This type of lesion has been called "Saturday night palsy" or "sleep paralysis." Rarely it has been observed in long, wasting illnesses due to pressure of the arm against the bed. Radial nerve lesions have occurred as the result of malposition during a prolonged anesthesia and occasionally it has been observed as the result of carrying very heavy objects, or severe sudden stretching of the extremity. The local reaction which follows therapeutic injections of ether, arsphenamine or serum has resulted in partial paralysis of the nerve. Just as there are certain individual characteristics in the recovery of each nerve from a lesion, so may we class the vulnerability of radial nerve to injury since relatively minor injuries always produce a complete motor paralysis.

Motor Symptoms

The radial is the nerve of extension of the upper extremity. When it is paralyzed, extension of the thumb, proximal

phalanges of the fingers, wrist and elbow and abduction of the thumb on the plane of the palm are impossible. The wrist and fingers are flexed in a position which is termed "wrist drop,"

FIG. 139. Wrist drop deformity characteristic of radial nerve paralysis.

and the thumb is adducted and held in the line of the outer border of the index finger (Fig. 139).

In radial nerve paralysis, some muscles not supplied by it function feebly and awkwardly. The flexors of the wrist and fingers are especially affected. The patient cannot adequately

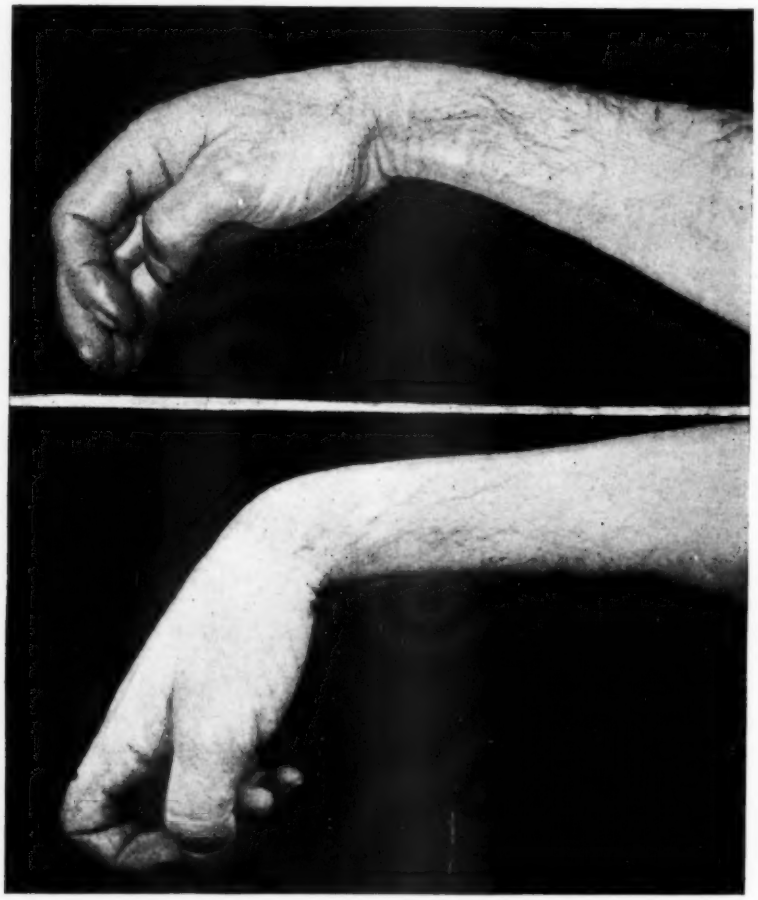

FIG. 140. Inability to close fingers completely in radial nerve paralysis.

make a fist or grasp objects in his hand because complete flexion of the fingers is impossible, due to the impossibility of shortening the distance between the origin and insertion of the extensors of the wrist and fingers by extension at the wrist. (Fig. 140.) The thumb frequently interferes with flexion of the index finger, and the patient must move it aside with the unaffected hand. Unless the hand is placed flatly upon the table,

abduction and adduction of the fingers is difficult. Due to distention of the ligaments of the wrist and thickening of the synovial membranes, the metacarpal bones protrude, forming the well-known "tumor of the wrist."

The best method of testing the function of the triceps muscle is to allow the patient's arm to hang over the back of a chair with the upper portion horizontal and the forearm hanging loosely at right angles to it. The patient is then asked to straighten his arm. The muscle may then be inspected and palpated during the attempt to extend the forearm. Care must be exercised not to misinterpret that extension of the forearm which occurs from a flexed position as the result of gravity controlled by the flexors as true extension. For this reason it is important to have the patient raise his elbow high enough so that it becomes impossible for him to extend the bended forearm by reason of the weight alone. Another way to test the paralysis of the triceps is to extend the elbow, then to ask the patient to resist any attempt to flex the forearm on the arm. Because the long head of the triceps receives its motor supply immediately after the nerve emerges from beneath the tendon of the teres major, complete loss of extension of the forearm is infrequent in radial paralysis.

The brachioradialis muscle is brought into action when flexion of the elbow is attempted with the forearm semipronated. With the extremity in this position the patient is asked to resist extension at the elbow. Under this condition an unparalyzed brachioradialis will stand out prominently. Contrary to generally accepted statements that the biceps cannot aid in supination unless the elbow is partly flexed, attention must be called to the fact that at times the biceps supinates the forearm even when it is completely extended.

Weakness of the extensors of the wrist is observed when the patient attempts to raise the hand against the action of gravity. Care should be taken to keep the elbow and forearm of the patient motionless and resting on a table, with the hand loosely suspended and pronated. When the extensors of the wrist

are paralyzed no contraction is felt during the attempt at extension, while, on the contrary, there is energetic contraction of the flexors of the hands and fingers. Inversely, attempt at

FIG. 141. Lesion of radial nerve which paralyzed extensors of fingers but not those of wrist.

flexion of the fingers does not produce a synergistic extension at the wrist, and it will be found that the patient can neither close his fist nor flex all the phalanges completely. The third phalanges will flex weakly or not at all. To verify lateral movements at the wrist, the possibility of error arising from movement of the elbow should be eliminated by resting the forearm on a table, but the hand should be raised almost to the horizontal instead of being allowed to drop. A certain amount of abduction is possible in paralysis of the extensors through the action of the flexor carpi ulnaris. This abduction, however, is incomplete and faulty, and is accompanied by ventral ulnar deviation.

In a lesion of the radial nerve below the elbow, paralysis of the extensors of the fingers may occur without involvement of the extensors of the wrist (Fig. 141). Under these conditions the patient cannot extend the wrist if, at the same time, he attempts to extend the fingers. However, if he flexes the fingers extension of the wrist may then be accomplished. To explain this we must recall the laws governing the action of the

muscles which pass over several joints. Beevor has stated that "when a muscle by passing over two or more joints has two or more different actions, then if only one of these actions be required, other muscles are brought into the movement whose actions are antagonistic to those of the muscles not required." These synergic muscles place the prime movers (in this instance, the extensors of the wrist) in the greatest elongation so as to augment their dynamic power and fix the joint so that the movement may be performed from a secure basis. Still another factor must be considered. Beevor has found that "if the movement of extending the wrist be performed with the fingers actively and fully extended, the extensors of the fingers have to do all the work themselves and against the contraction of the flexors carpi until the amount of work amounts to four or five pounds before the extensors carpi will join in and help them." In the cited instance of paralysis of the extensors of the fingers with preservation of the extensors of the wrist, the extensors of the fingers cannot possibly reach the amount of pull which is necessary before the extensors of the wrist can be made to contract.

SUPPLEMENTARY MOVEMENTS: In a lesion of the radial nerve with paralysis of the extensors of the wrist, dorsal flexion of the hand may be produced by the action of muscles not innervated by the radial nerve. This may occur as the result of energetic contraction of the flexors of the fingers (Fig. 142). This occurs under certain conditions and is noted frequently. When the wrist drop does not exceed an angle of 120 degrees complete flexion of the fingers produces extension at the wrist. In this condition the extensors of the wrist are shortened by contracture and fibrosis so that the angle between the hand and forearm is such that passive dorsi-flexion or dorsal dislocation of the hand occurs. Without this provision the fingers could not be completely closed because of the shortened extensor tendons. The mechanism may be illustrated by using the wrist as a hinge, the hand as the weight and the flexors as the power transmitted through a pulley at the metacarpopha-

langeal joint to a fixed point at the origin of the extensors of the wrist.

In some cases strong contraction of the pronator radii teres

A

B

FIG. 142. Extension of wrist in radial nerve paralysis by supplementary action of flexors of fingers.

will produce extension of the hand on the forearm (Fig. 143). During this movement the head of the radius is strongly depressed toward the palm, the styloid process of the ulna is pulled dorsally and the hand is deviated to the ulnar side. It can be demonstrated readily that the hand can be flexed to a greater degree when the forearm is supinated than when it is pronated. If flexed to its fullest degree when the forearm is supinated, the hand will be seen to extend when strong pronation is instituted. The extension at the wrist is probably due to

two factors: first, increase of the distance between the origin and insertion of the extensors and, second, to a leverage exerted on the scaphoid by the head of the radius. At times, in

FIG. 143. Extension of wrist by supplementary action of pronator radii teres muscle in radial nerve paralysis.

addition to the contraction of the pronator, there is seen strong adduction and apposition of the thumb against the proximal phalanx of the index finger. At the same time resistance to this action is made by the contraction of the lumbrical muscles and the hand is extended on the forearm to a notable degree. During this action the middle, ring and little fingers show flexion at the proximal phalanges and extension of the two distal phalanges. Contrary to the opinion of Duchenne and Bénisty, when examined the American material showed, in agreement with Beevor and Mackenzie, that for pure lateral movements of the wrist the extensors and flexors are both necessary. Adduction and abduction of the wrist are superseded by pronation and supination of the forearm in the position of wrist drop of a radial palsy. If, however, the hand be extended passively to the same plane as that of the forearm, adduction accompanied by flexion of the wrist ensues as the result of contraction of the flexor carpi ulnaris, and occasionally abduction has likewise been observed.

The extensors of the fingers extend the first phalanges of the fingers on the metacarpal bones, and only the first phalanges. To demonstrate the immobility of the first phal-

anges it is necessary to have the wrist passively semi-extended (Fig. 144). Under this condition no extension will take place at the first phalanges. It is possible to tense the proximal

FIG. 144. Hand must be in this position to test accurately extension of proximal phalanges.

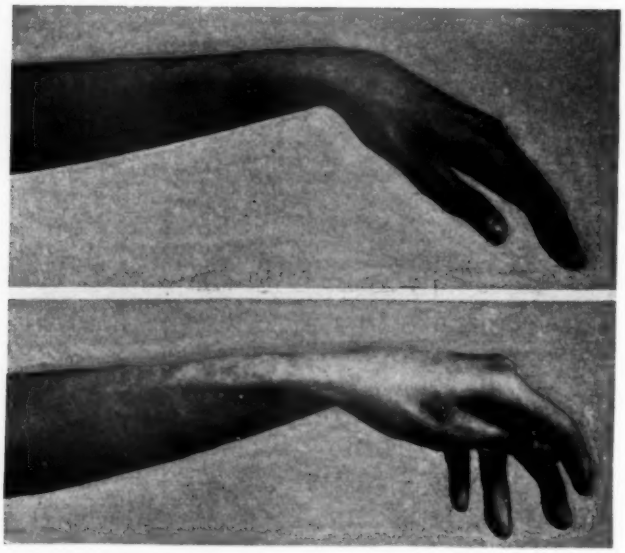

FIG. 145. Extension of wrist in radial nerve paralysis by action of pronator and extension of proximal phalanx of index finger by pressure from thumb.

phalanges of the fingers by extending the terminal ones through the interossei. At the same time, flexion of the proximal phalanges occurs as the result of the unopposed action of the lumbricales. Slight passive extension of the proximal

phalanges may be produced by flexion of the hand at the wrist. Simulation of extension of the first phalanx of the index finger is frequently accomplished by strong adduction

FIG. 146. Attempt to extend distal phalanx of thumb against resistance by use of supplementary muscles.

and opposition of the thumb against the first phalanx of the index finger, which is thereby passively lifted dorsally (Fig. 145).

The extensor longus pollicis extends the two phalanges of the thumb. In addition to it, however, the abductor and adductor pollicis and flexor brevis pollicis are prime movers for extension of the distal phalanx of the thumb. Therefore, although never as complete or as strong as when the extensor longus pollicis is spared, the other muscles may produce extension of the distal phalanx of the thumb (Fig. 146). Simulation of this movement may be produced by flexion of the distal phalanx of the thumb followed by relaxation. Such a mechanism is frequently observed in slight flexion of the fingers in ulnar-median nerve lesions, and flexion and extension of the toes in tibial-peroneal nerve lesions respectively. Abduction of the thumb in the plane of the palm is

impossible in radial nerve paralysis and during attempts to abduct the thumb the tendons of the anatomical snuff box do not stand out in the slightest degree.

Sensory Symptoms

Subjective sensory disturbances are rare in radial nerve lesions. Pain is present commonly as the result of injury to other tissues. Pricking, numbness and occasionally pain may be complained of on the dorsum of the forearm or thumb. Rarely a case of burning pain or causalgia has been reported, and in such instances it is possible that the median nerve as well has been injured.

Objective sensory loss is often overlooked because of the widespread overlap to painful sensibility and failure to shave the parts examined. Hamilton, in a careful study, showed that although a lesion of the radial nerve at any point produces less sensory disturbance than one would expect considering its anatomic distribution, it is rarely if ever that some definite area of sensory loss may not be found if it is carefully sought.

In lesions of the nerve in the middle third of the arm, which is the most common level of injury, the internal cutaneous branch is rarely involved. In Hamilton's fifty-five cases in only one instance was the radial nerve injured sufficiently high to produce a loss of sensation in all three of its branches. In twenty-seven instances there was a definite area of sensory involvement in the forearm as well as the hand. In common with our material, the sensation was lost most frequently over the superficial radial nerve distribution. We have never found a case of complete section of the radial at or above the elbow in which sensation was not lost over the distribution of this latter nerve. The area of loss of pain to pin prick is variable and may be completely absent because of the overlap of adjacent uninjured nerves. The loss of sensation to cold and heat of moderate degrees follows the loss of tactile sense, but the preservation of sensation to higher degrees of temperature

is coextensive with the loss to pain. Sense of position is not notably impaired, but vibration sense is defective over the thumb.

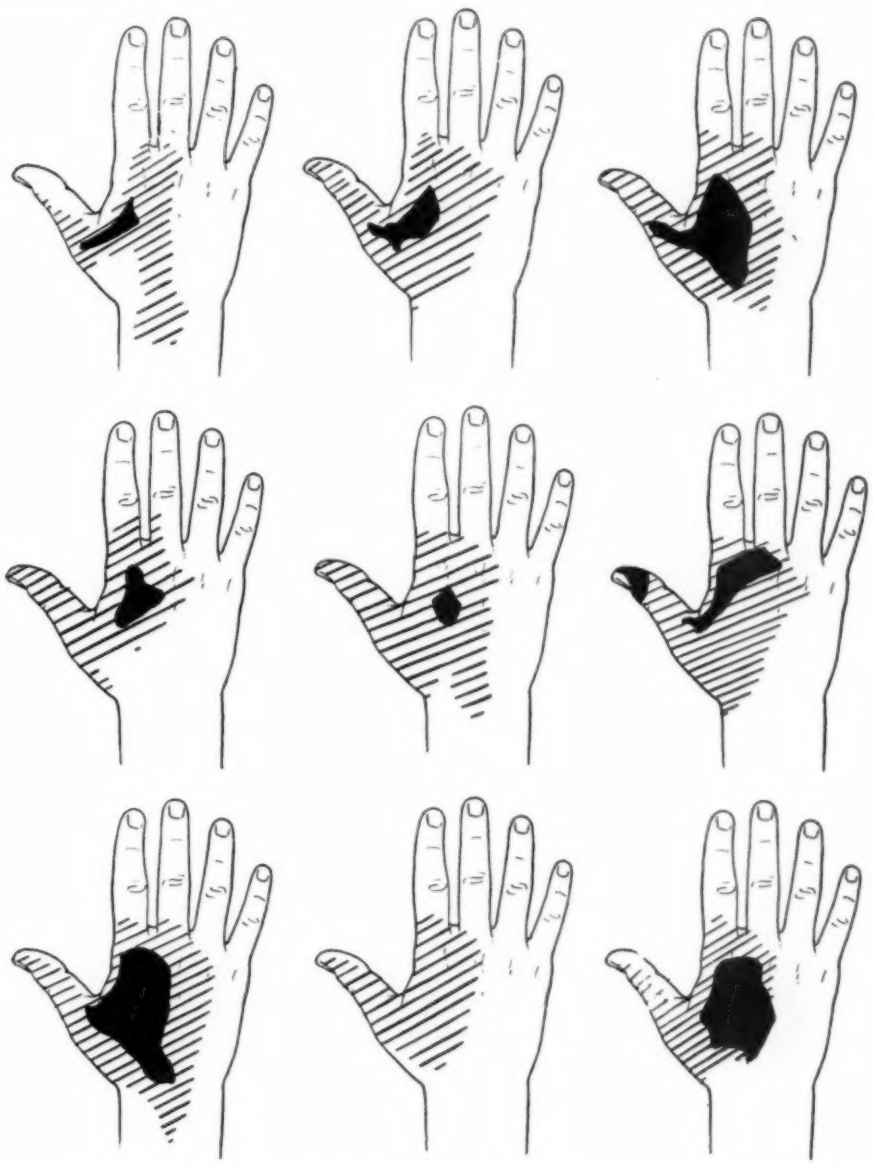

FIG. 147. Variability of loss of pain in a radial nerve lesion soon after injury.

The cases of radial nerve lesions, certified at operation or examined less than thirty-seven days after resection and

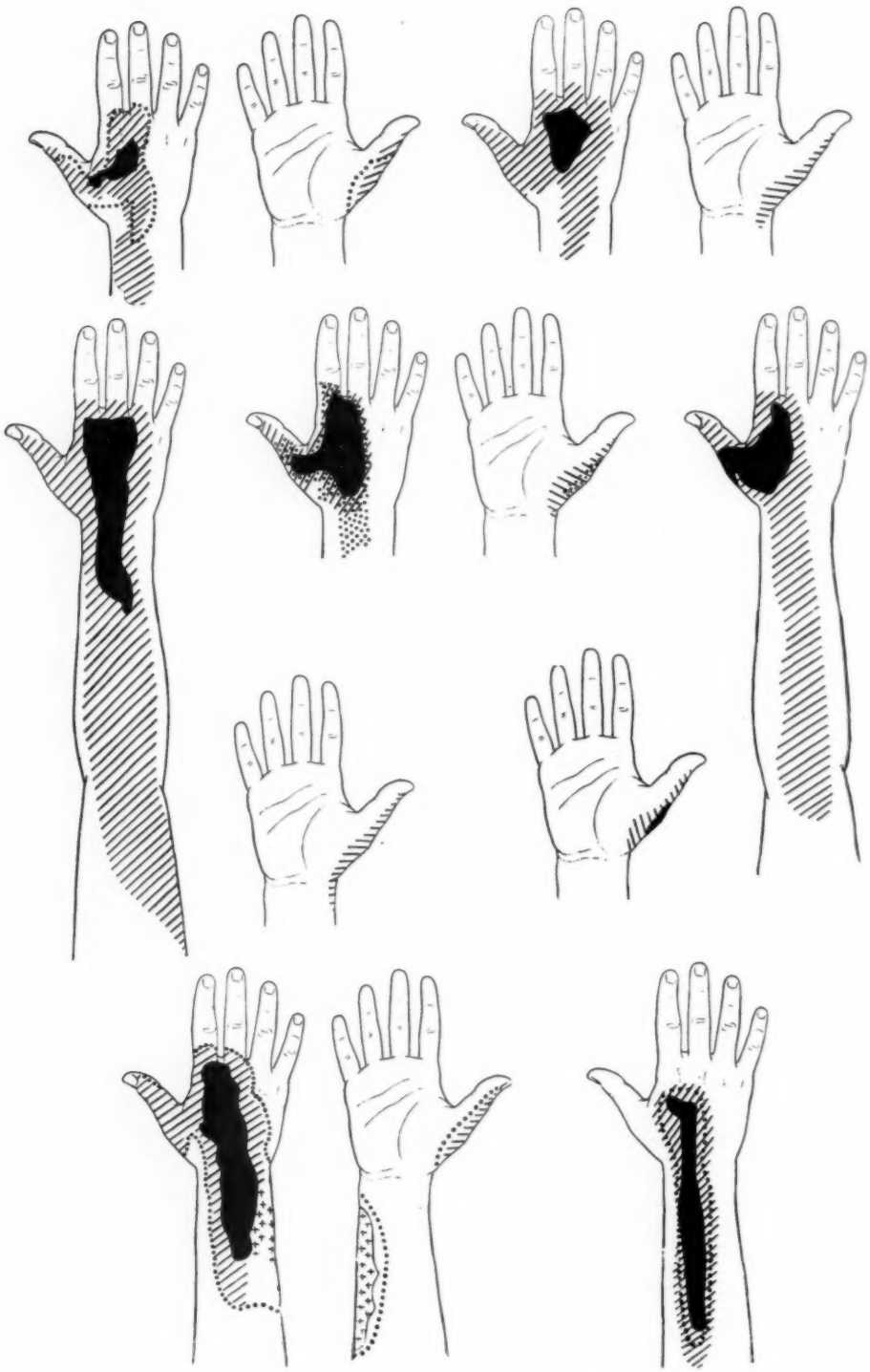

FIG. 148. Patterns of sensory loss in radial nerve lesions.

[578]

suture, showed a wide variety of areas of analgesia and in one case no analgesia at all (Fig. 147). Head and Sherren's Case 44 of division of the radial nerve where it passes under the tendon of the brachioradialis likewise showed no loss to prick pain.

Although not infrequently recorded, we have not observed any case of radial nerve lesion which did not show loss of sensation to touch. Of all the peripheral nerves, the radial shows the greatest variation in the areas of loss of sensation to both epicritic and protopathic sensation. This is due to the fact that six nerves are concerned with the sensory supply of the dorsum of the hand; the median, superficial radial, external cutaneous branch of the radial, musculocutaneous and ulnar. Stopford emphasized, as did Head and Sherren, the importance of the musculocutaneous nerve in the supply of the dorsum of the hand, and states that its terminal branches may extend onto the dorsum of the metacarpus, and "it appears that the extent of its distribution varies inversely with that of the radial." Although this may be true, it must not be forgotten that the median nerve must be considered in the supply of sensation to the dorsal area over the distal portion of the metacarpus and the distal portion of the thumb. (Fig. 148.)

One of the reasons for varying reports relative to the sensory loss in radial nerve lesions is the hairy nature of the area of skin under investigation. The early return of hair sensibility frequently is confused with the presence of sense of touch. The skin must be closely shaven in all cases when examination of touch is contemplated. When examinations were made in the presence of hair, areas sensitive to "touch" frequently were analgesic.

Vasomotor or secretory disturbances are absent or very slight and usually occur as the result of a complicating vascular, osseous, articular or muscular injury. At times slight edema and some induration of the skin over the dorsum of the forearm have been observed.

Level of Lesion

If in addition to a paralysis of the muscles supplied by the radial nerve the deltoid is paralyzed, the lesion involves the

Fig. 149. Method of testing paralysis of brachioradialis muscle.

posterior cord of the brachial plexus. In the middle of the forearm, a wound may produce only a partial paralysis of the triceps, since the branches to the long and inner heads of the muscle may come off at a higher level. In the lower fourth of the arm the branches to the brachioradialis, and less frequently the extensor carpi radialis, may have been given off at a higher level (Fig. 149).

Partial Lesions

It is significant that in lesions of the radial in the arm it is usual to find all the muscles below the innervation to the brachioradialis paralyzed, irrespective of the severity of the lesion. However, it may be noted that at times the extensors of the wrist may be paralyzed and those of the fingers remain unaffected. Again, only the extensor of the middle finger may be

unimpaired (Fig. 150). Occasionally the extensors of the thumb and fingers may be involved, whereas the extensors of the wrist are spared (Figs. 151 and 152). The constancy of certain partial

FIG. 150. Partial conservation of extensor to middle finger in radial nerve lesion.

FIG. 151. Paralysis of extensors of thumb and index finger in radial nerve lesion.

lesions of various nerves has been attributed to the intraneural localization of fibers which supply certain muscles, as has been

pointed out by Stoeffel, Marie, Meige, Gosset, Dejerine and Mouzon, and Krauss and Ingham. However, it may be well to remember that Dustin believes that he has shown conclu-

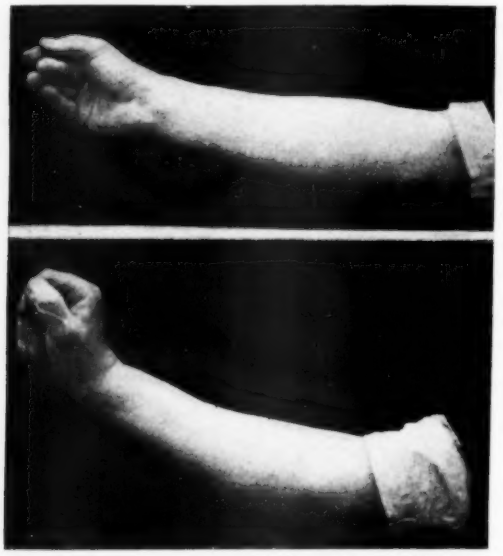

FIG. 152. Paralysis of extensors of thumb in radial nerve lesion.

sively that between each branch of a nerve there is a reassembling of nerve fibers in the form of an intraneural plexus, so that a long intraneural pathway does not exist.

MUSCLE ATROPHY

Muscular atrophy is noted two or three months after the injury and may become so marked that it appears as if the skin and subcutaneous tissue were adherent to the posterior aspect of the ulna and radius.

SIGNS OF MOTOR RECOVERY

According to Oppenheim, the muscles recover in direct relation to the length of the regenerating nerve fibers. This does not appear to be the case. Bénisty stated that the order of recovery is nearly always the same. The common extensor is restored only after the radial extensors. Usually the extensors

of the middle, ring and little fingers begin to recover first; but sometimes it is the index and middle fingers which first recover their movements. The extensors of the thumb and the adductor

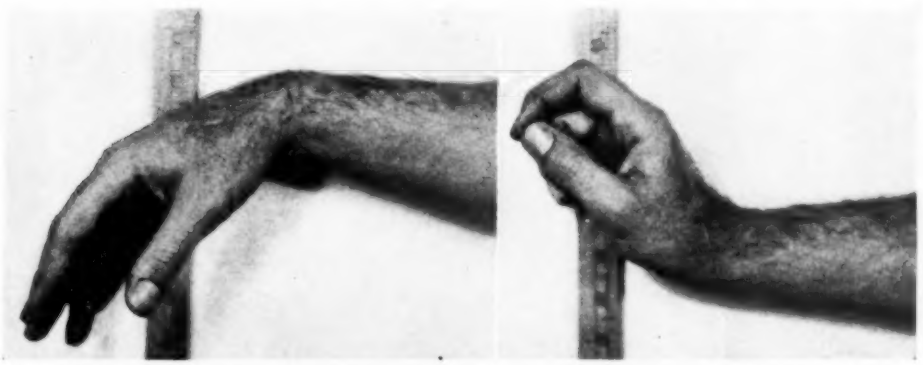

FIG. 153. Recovery of radial nerve palsy following neurolysis. Note recovery of extensors of wrist and supplementary movement of index finger.

FIG. 154. Recovery of extensors of wrist but not of thumb or fingers.

of the thumb regain their power last of all. From the available observations of the United States war material, a marked difference is seen in that the extensors of the thumb recovered before those of the fingers. As to the order of recovery of the extensors of the fingers and thumb, those of the thumb showed some recovery in over 50 per cent of our cases, but when this did not occur the thumb was almost the last to recover. The extensor of the middle finger was one of the first to recover in over 50 per cent of cases and the index finger was last in one-

third of the number of cases. Rarely, return of function was seen in the long abductor of the thumb before that in the extensors of the wrist (Figs. 153, 154, 155).

FIG. 155. Recovery of extensors of wrist and partial recovery of extensors of fingers.

Simultaneous extension of the wrist and all of the fingers seems to be the final stage in recovery of voluntary movement. Pitres suggested two tests for determining the completeness of recovery in radial nerve paralysis. The first test consists in placing the arm in the attitude of a man taking an oath with the wrist and fingers extended, the thumb raised and separated from the fingers with the tendons of the extensors and the long abductor of the thumb marking out the anatomical snuff box. Then the patient is requested to supinate his hand. The second test consists of the patient placing his little finger on the seam of his trousers, with his fingers well extended and with the palm turned to the front (Fig. 156).

SIGNS OF SENSORY RECOVERY

Here, as in other nerves, interlacing of the borders of the loss of sensation to heat, cold, pain and touch and recovery of tactile sensibility, particularly in islands away from the border of former loss, constitute evidence of recovery.

Radial nerve lesions in many instances showed areas of loss of cold with recovery of tactile sensation. In lesions of this nerve, the return of sensibility to pain alone cannot be given

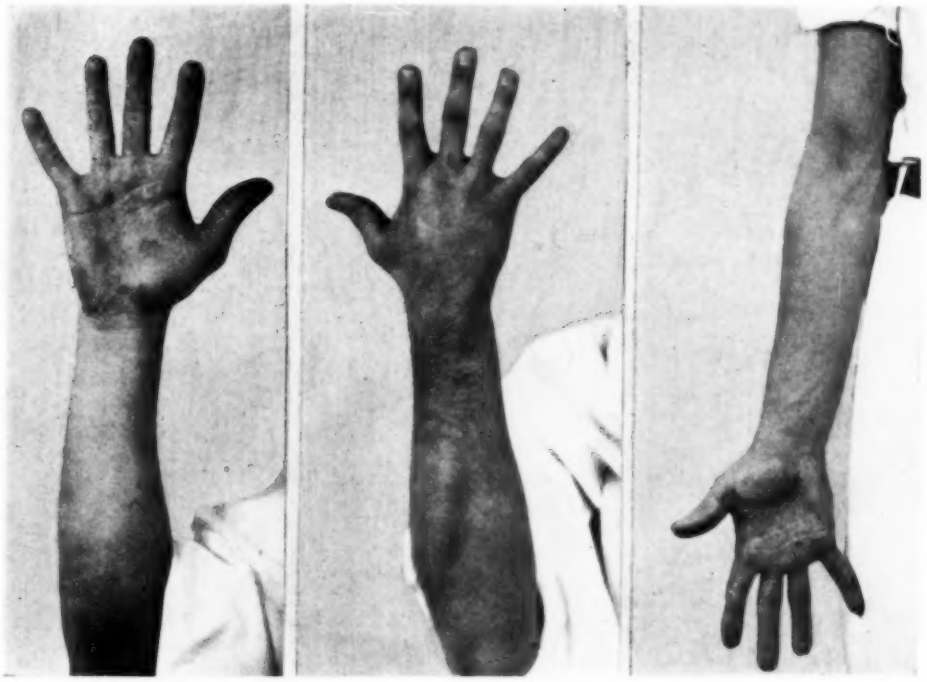

FIG. 156. Tests for complete recovery of motor function in radial nerve lesion.

much weight in relation to regeneration, because of the very wide overlap of adjacent nerves. Patchy return of sensation, interlacing of the borders of loss to cold, areas of recovery of tactile sense and not of cold, and the reverse, as well as the recovery of tactile sense in the sensory supply of the nerve, served to determine the existence of a process of recovery. In some cases an area of widespread anesthesia was present, but a deep indentation pointed to the correct diagnosis. Similarly, a wide area of anesthesia and analgesia would have been deceptive had not the border of the loss to cold been well outside this area and interlacing of cold been present (Fig. 157).

Bénisty refers to a diffuse, burning pain which follows pinching of a formerly anesthetic area as an early sign of

regeneration. This may occur but it is not an accurate indication. Neither have we found Tinel's sign to be entirely reliable.

Due to the extensive overlap of adjacent nerves, there is no

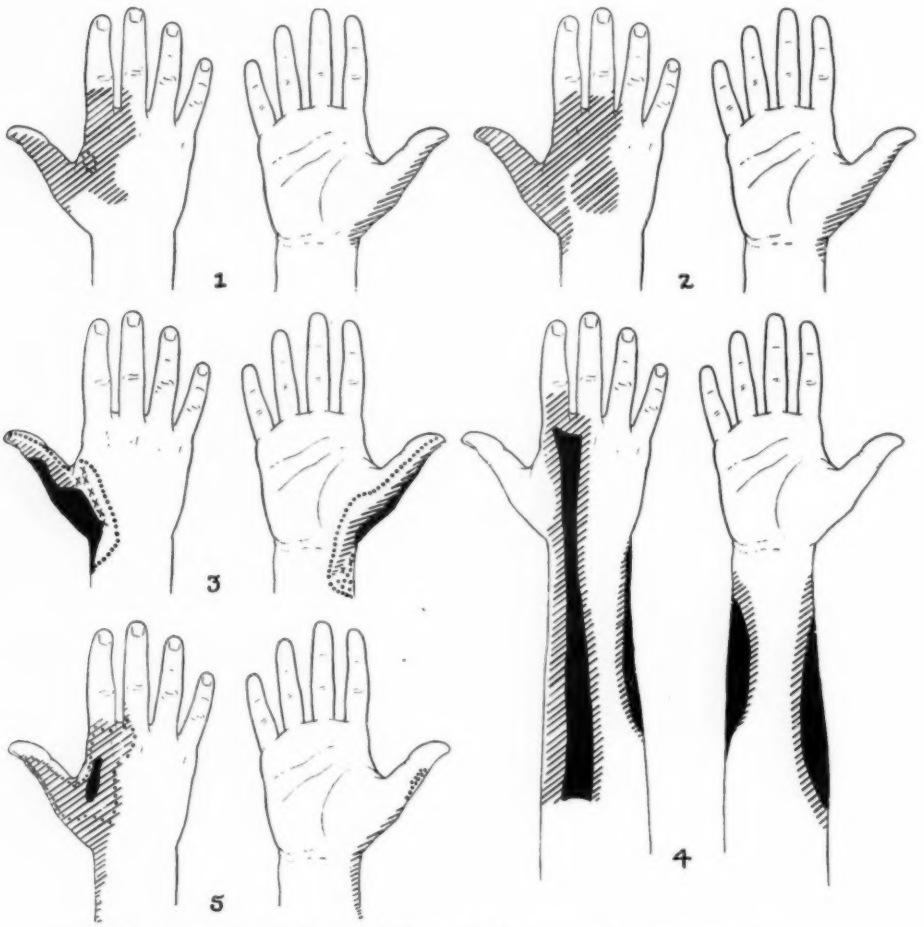

FIG. 157A. Radial nerve lesions which recovered spontaneously.

1. Recovery of pain, small area of loss of cold.
2. Recovery of pain and cold.
3. Injury of superficial sensory nerve, recovery of touch, not pain.
4. Recovery of all motor branches, marked sensory loss.
5. Recovery of cold, not touch.

isolated area of sensory supply of the radial nerve, and special attention must be given to the general principles indicated above. Return of sensation to milder degrees of heat and cold

within an area anesthetic to tactile stimulation, or the return of tactile sensibility within the area of loss to mild cold or heat, are certain signs of recovery.

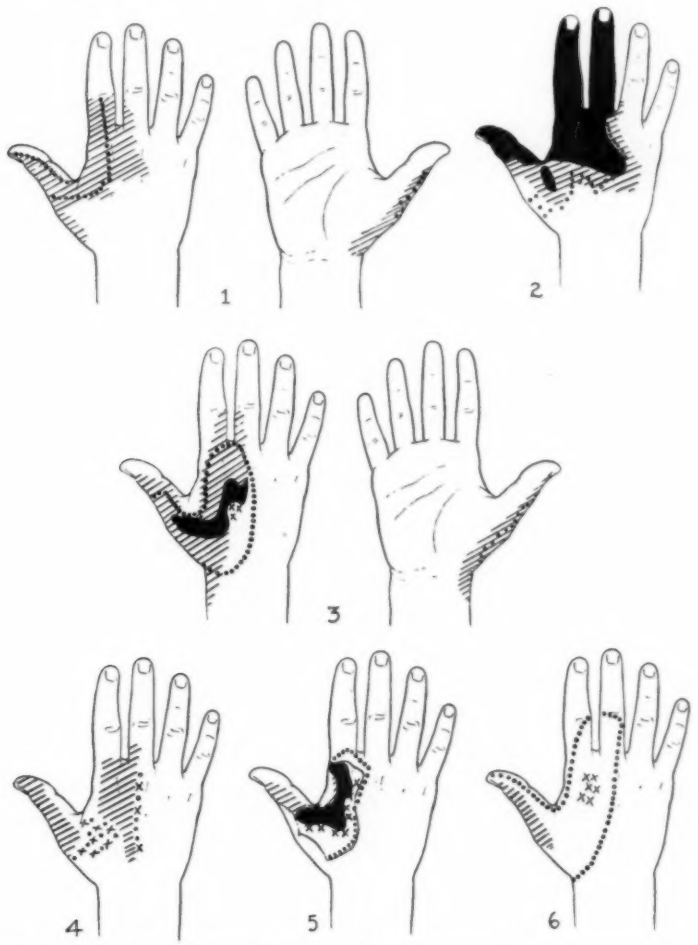

FIG. 157B. Radial nerve lesions which recovered after operation.

1. Return of pain, not cold.
2. Radial and median nerve lesion showing considerable analgesia; island of analgesia.
3. Recovery of touch, not cold, and recovery of touch and not pain.
4. Return of touch, not pain, in a patch; shaded area showed only tactile hypesthesia.
5. Return of touch, not pain or cold.
6. Return of touch and pain, not of cold.

DIFFERENTIAL DIAGNOSIS

The diagnosis of an injury to the radial nerve is usually made readily. Vascular lesions, ischemic paralysis, bony

ankylosis and, especially, injury to tendons may lead to confusion. In cases of severed tendons, although no movement of the hand or fingers is produced, electrical stimulation produces contraction of the muscles suspected of being paralyzed. The same is true in ankylosed and painful joints. In ischemic paralysis muscles are involved other than those supplied by the radial nerve; the reaction of degeneration does not occur and the sensory loss is inconstant and does not follow the anatomic distribution of the nerve. The condition known as "congealed hand" due to "physiopathic reflex nervous disturbance" may offer some difficulty in diagnosis, but the lost motion is not limited only to the muscles supplied by the radial nerve. In such cases electrical excitability is increased, the extremity is cold, the pulse small, and the sensory loss, if any be present, does not follow any anatomic distribution.

Anatomy

The radial nerve is one of the two branches of the posterior cord of the brachial plexus. Therefore, it consists of fibers of the posterior divisions of all of the spinal nerves which form the brachial plexus. It is the largest branch of the brachial plexus.

In the axilla the radial lies beneath the axillary artery which gives off a branch to supply the nerve. The other nerves in the axilla are on a plane anterior to the radial. The median is separated from it by the axillary artery and the musculocutaneous lies still more anteriorly. The ulnar and internal cutaneous nerves to the arm and forearm are anterior and medial to it.

The radial crosses the anterior surface of the tendons of the teres major and latissimus dorsi muscles. It has variable relations to the numerous branches of the axillary artery which arise at this level. In many instances the inferior scapular artery arises from the axillary external to the nerve and the latter then crosses its anterior surface to reach the triangular space bounded by the subscapular, teres major and the long head of the triceps muscles.

The nerve continues downward into the arm after entering the fascial plane between the long and lateral heads of the triceps. It lies closely applied to the inner side of the humerus. It then descends along the posterior surface of the humerus in the spiral groove. It is completely masked by the lateral head of the triceps. In its course across the posterior surface of the humerus the nerve is accompanied by the superior profunda artery. At the lateral side of the humerus the artery gives off two branches, the smaller of which accompanies the nerve. The larger branch of the artery passes down along the posterior surface of the intermuscular septum to the level of the lateral condyle of the humerus (Fig. 158).

About 10 cm. above the lateral epicondyle the nerve, with its artery, pierces the external intermuscular septum and descends on the anterior aspect of the arm, lying upon the anterior surface of the brachialis anticus muscle. The brachioradialis lies anterior and lateral while the tendon of the biceps lies anterior and medial to the nerve. At the level of the lateral condyle of the humerus or slightly above, the radial divides into its terminal branches, the *posterior interosseous* and the *superficial radial* nerves. It is obvious that the radial lies medial, posterior, lateral and anterior to the humerus as it passes from its origin to the point at which its terminal branches arise.

As the radial lies medial to the humerus three branches are given off close together. The *internal cutaneous branch* must not be confused with the medial cutaneous nerve to the arm. It arises from the nerve in the axilla and crosses the anterior surface of the teres major and latissimus dorsi tendons. It descends along the medial border of the long head of the triceps and finally passes posterior to that muscle to perforate the aponeurosis on the posterior surface of the arm. Its terminal twigs anastomose freely with those of the internal cutaneous nerve of the arm. The *muscular branch* to the *long head* of the *triceps* is usually 3 to 4 cm. long. It descends along the medial border of the muscle and divides into two or three branches which ramify upon the anterior surface of the muscle before

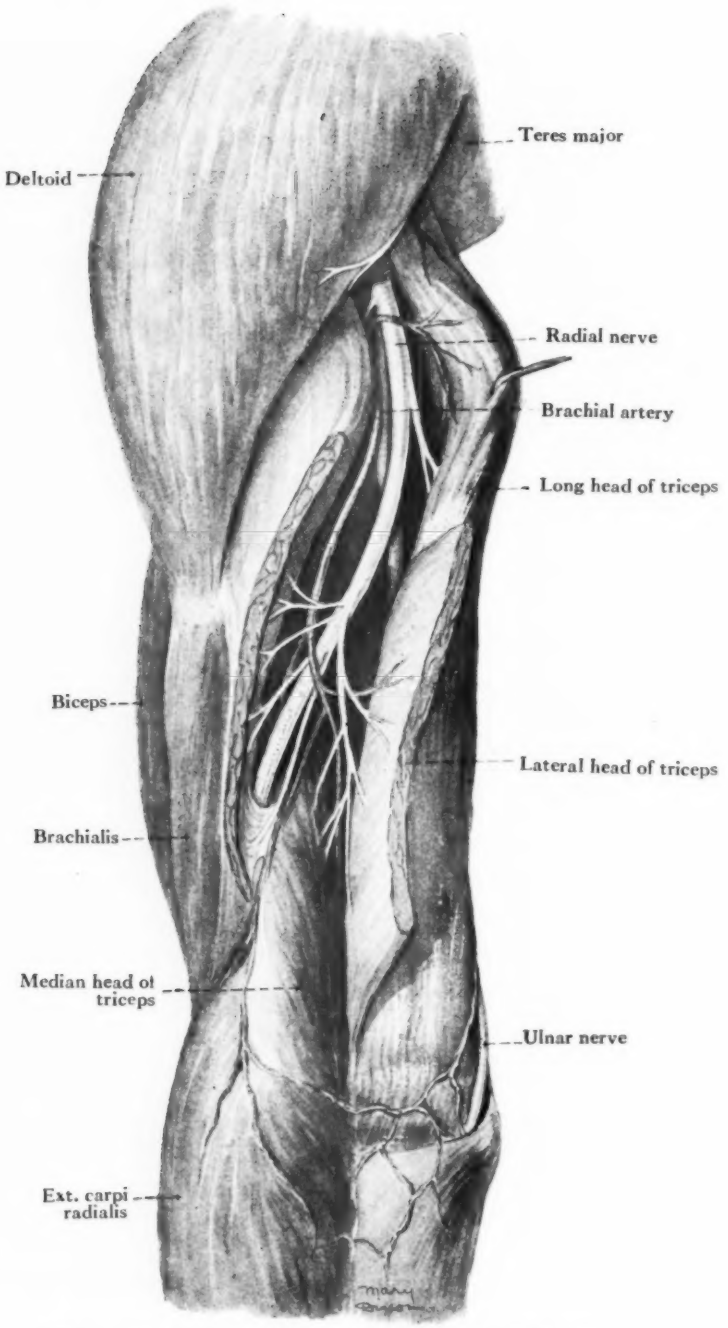

FIG. 158. Anatomical course of radial nerve in arm.

penetrating it. The *superior branch* to the *medial head* of the *triceps* arises from the radial in the axilla just below the branch to the long head. It may be contained in the same sheath with the ulnar and thus it is also known as the ulnar collateral. At a variable level it penetrates and supplies the medial head of the triceps.

As the radial lies posterior to the humerus several branches are given off. The *muscular branch* to the *lateral head* of the *triceps* passes downward and externally and quickly divides into numerous twigs which penetrate the medial side of the lateral head. The *inferior branch* to the *medial head* of the *triceps* is the principal nerve supply to this muscle. It also innervates the anconeus muscle and the elbow joint. It follows the trunk of the radial in the groove and lies parallel to the superior edge of the medial head. It is easy to trace as it passes downward because of the numerous branches it gives to this muscle. At the lower border of the medial head of the triceps it supplies the anconeus with numerous twigs. Throughout its course it is accompanied by a small artery, a branch of the profunda. The *external cutaneous* nerve arises from the radial as it courses through the spiral groove. It is quite large and quite frequently parallels the main nerve trunk. It perforates the lateral head of the triceps and the brachial aponeurosis at a variable point above the epicondyle. It then divides into a superior and an inferior branch which supply the skin over the lateral surface of the arm and the dorsal surface of the forearm. These branches anastomose with branches of the musculocutaneous and medial cutaneous nerve to the arm.

As the radial lies anterior to the intermuscular septum it gives off a branch to the *brachialis anticus* muscle. At a slightly lower level, about 5 to 6 cm. above the medial condyle, the branch to the *branchioradialis* arises from the lateral border of the nerve. Approximately 1 cm. lower the branch to the *extensor carpi radialis longus* muscle arises from the lateral side of the nerve. Stookey points out that the branch to the *extensor carpi radialis brevis* muscle arises from the same

funiculus as the former branch. It has a long extraneural course before it supplies the muscle.

The radial ends a few centimeters above the lateral condyle of the humerus where it divides into two terminal branches; the superficial *radial* and the *posterior interosseous nerves* (Fig. 159).

The superficial radial nerve is the smaller of the two and descends lateral to the biceps tendon. It lies beneath the brachioradialis muscle upon the brachialis anticus and is accompanied by the anterior recurrent radial artery. At the junction of the middle and inferior thirds of the forearm the nerve passes externally between the tendon of the brachioradialis and the radius. It reappears at the lateral border of the brachioradialis tendon between it and the extensor of the thumb. Here it perforates the aponeurosis. In its course through the forearm the nerve is related closely to the radial artery. If the nerve is not found in the vascular sheath, it is contained in the fascial sheath of the brachioradialis. About 4 cm. below the styloid process of the radius the nerve divides into its terminal branches. Usually these are two; one external and one internal. The external branch lies behind the tendon of the long abductor and courses in the subcutaneous tissue on the dorsum of the thumb, often as far as the terminal phalanx. Occasionally small collaterals of this branch may reach the skin over the thenar eminence. The *internal* branch is larger and soon after its origin gives off twigs to supply the skin on the dorsal surface of the wrist. Some of these anastomose with the dorsal cutaneous branches of the ulnar. In the first interosseous space it divides into the dorsal digital nerves on the radial and ulnar sides of the index finger and the radial side of the middle finger.

The posterior interosseous nerve is more deeply placed than the superficial radial. It lies for a short distance in the external bicipital groove and then passes between the brachioradialis and brachialis anticus muscles. It is crossed by rather large arterial branches which supply the muscles in this area.

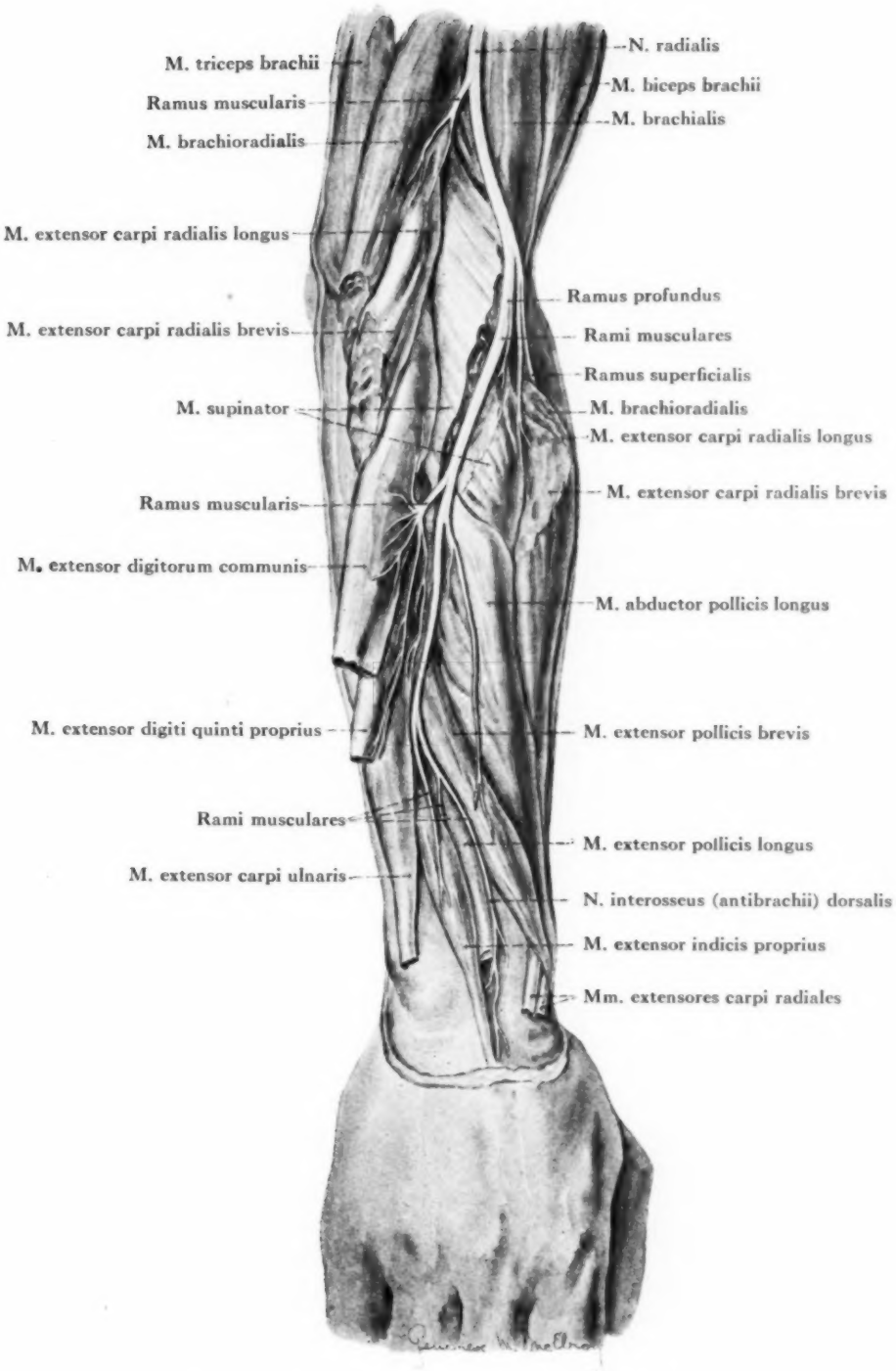

FIG. 159. Anatomical course of radial nerve in forearm.

The nerve then passes to the outer side of the radius beneath the external carpi radialis longus and brevis muscle. It turns around the head of the radius in an oblique manner and pierces the supinator brevis muscle to which it gives branches. It now occupies the space between the two superficial and deep muscular layers on the posterior aspect of the forearm. Just below its exit from the supinator brevis the posterior interosseous nerve ends by dividing into two or more main twigs which again rapidly divide. The nerve becomes flattened and bandlike and loses the appearance of a nerve trunk. Of these terminal branches one is relatively large and has a short extramuscular course before it supplies the extensor digitorum communis, the extensor carpi ulnaris and extensor digiti quinti proprius muscles. The other terminal branches have a long extramuscular course and supply the abductor pollicis longus, extensor pollicis brevis and extensor indicis proprius muscles.

Physiology

The radial nerve may be called the nerve of extension. The *triceps* muscle extends the forearm upon the arm. Duchenne has shown that the long head of the triceps is the weakest because it has no stability in its upper attachment. The *anconeus* also extends the forearm and even when the triceps is completely paralyzed its strength of action is such that it alone can extend the forearm.

In spite of its old name the *brachioradialis* (supinator longus) forcibly flexes the forearm upon the arm when the hand is held midway between supination and pronation. The *supinator brevis*, on the contrary, is a supinator exclusively. The *extensor carpi radialis brevis* simply extends and abducts the hand while the *extensor carpi ulnaris* extends and adducts the hand.

The *extensor communis digitorum, extensor indicis proprius* and *extensor minimi digiti quinti* muscles extend the first phalanx of the fingers on the metacarpal bones and only the

first phalanx. Extension of the second and distal phalanges is accomplished by the interossei and lumbricales.

The *extensor pollicis longus* extends the two phalanges of the

FIG. 160. Line of incision to expose radial nerve in axilla.

thumb and at the same time slightly extends the hand. The *extensor pollicis brevis* is a direct abductor of the first metacarpal and is the only muscle to perform this action. The *abductor pollicis longus* draws the first metacarpal obliquely outward and forward. In addition, its complete contraction flexes the hand and inclines it outward.

SURGERY

Lesions of the radial within the *axilla* are usually associated with vascular injury. The method of exposure is similar to that employed in low brachial plexus lesions. The arm is placed at right angles to the body and in external rotation. The incision may be a straight one from the base of the axilla to the middle of the humerus and parallel to the medial edge of the coracobrachialis muscle (Fig. 160). The deep fascia is divided and the neurovascular bundle is exposed. The nerve may be exposed between the axillary vein and the median nerve or it may be isolated by retracting the entire neurovascular bundle. To accomplish the latter it is necessary to ligate some of the small branches of the brachial artery and vein. The nerve should be identified as it passes over the tendon of the latissimus dorsi muscle. In this position it is accompanied by the superior profunda artery. In the order of appearance the branches of the radial at this level are the internal cutaneous, branches to

the long head of the triceps, the ulnar collateral branch for the medial head of the triceps and anconeus and the branch for the lateral head of the triceps. Some of the internal fibers of the medial head of the triceps may be severed to afford a satisfactory exposure of the nerve as it enters the groove on the posterior surface of the humerus.

As the nerve passes through the groove on the dorsal surface of the humerus, it is accompanied by the superior profunda artery and vein, both of which lie to its lateral side. The nerve, it will be remembered, is in direct contact with the humerus and is commonly injured in fractures of the middle third of the bone. It may be crushed by the trauma which produces the fracture or it may be stretched or traumatized by the bone fragments at the time of the injury or during efforts at reduction. Not infrequently the nerve may be found buried in the callus formed as the fractured ends unite. The nerve may be exposed in this situation by one of several methods. The almost vertical course of the radial is not appreciated fully. It has a spiral course only in a small part of the middle third. Thus there are certain disadvantages to a spiral incision which attempts to parallel the course of the nerve. In such an exposure a portion of the triceps must be cut transversely.

The most satisfactory incisions are those which are longitudinal in direction. An incision may be made from a point 7 cm. below the posterior angle of the acromion to another point about 5 cm. below the insertion of the deltoid muscle (Fig. 161). This should be placed in the middle of the posterior surface of the arm along a straight line which extends from this angle of the acromion to the tip of the olecranon. The deep fascia is incised and the plane of cleavage between the long and lateral heads of the triceps is deepened until the glistening aponeurosis upon their ventral surfaces is exposed. The separation of the heads of the triceps should be carried to the upper and lower angles of the wound. The posterior fibers of the deltoid should be retracted and if necessary some of these may be divided. The aponeurosis on the ventral surface

of the tricipital heads should be opened with care because the nerve lies just beneath.

When a large amount of scar tissue is present it is often

FIG. 161. Line of incision to expose radial nerve in upper arm.

necessary to supplement this dorsal incision with a lateral one which exposes the nerve as it appears on the lateral surface of the arm, after it has penetrated the external intermuscular septum. The lateral head of the triceps is separated from its septal attachment and is retracted dorsally. This will expose the lateral portion of the radial groove. A tape may be passed beneath the muscle and its ends used as a retractor so that the nerve may be followed throughout its course in the groove. Great care should be used to prevent injury to the tricipital branches.

In the lower third of its course in the arm the nerve may be exposed by a longitudinal incision which extends from the insertion of the deltoid to a point between the tendon of the biceps and the external condyle of the humerus (Fig. 162.) The cephalic vein is divided in the lower part of the incision and the lateral cutaneous nerves, if encountered above, may be sacrificed. The line of cleavage between the brachioradialis muscle laterally and the biceps and brachialis anticus muscles medially is deepened and these muscles are retracted. In this cleft the nerve with a small terminal branch of the superior profunda artery is found. The nerve should be identified well above the lesion and great care must be taken to preserve the motor branches which are given off in this location.

If sufficient exposure is not obtained a third incision between these two and parallel to the upper one may be made

from just above the deltoid insertion downward. It is carried through the triceps, the fibers of which are separated in a longitudinal direction. The aponeurosis described previously

FIG. 162. Line of incision to expose radial nerve in lower arm.

and the nerve from the lower border of the teres major muscle to the antecubital fossa, are exposed with the least damage to the surrounding structures.

When it is necessary to prepare a new nerve bed for the radial because of extensive scar tissue or callus, its course may

FIG. 163. Line of incision to expose posterior interosseous nerve.

be changed from the groove in the humerus to a lower position where it may be placed behind the medial head of the triceps. This requires that the nerve be mobilized throughout its lateral portion and that the lateral head of the triceps be separated from the external intermuscular septum low down.

To expose the *posterior interosseous nerve*, the terminal motor divisions of the radial, the arm is slightly flexed and the hand is placed in semipronation. The lateral condyle and the radial border of the common extensor muscle are identified. An incision is made from the lateral condyle down along the line between the extensor digitorum communis and the extensor carpi radialis longus and brevis through the deep

fascia (Fig. 163). The line of cleavage between them is found at the lower angle of the wound and this is deepened and carried upward to their common origin. Here the muscle fibers are

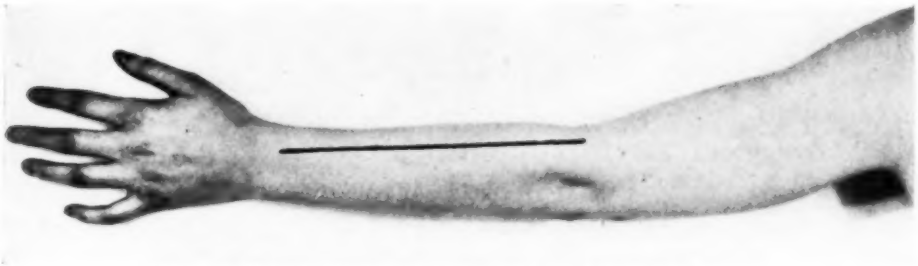

FIG. 164. Line of incision to expose superficial radial nerve.

divided parallel to their direction as far as the lateral condyle. By retraction of these muscles the obliquely directed fibers of the supinator brevis are identified. It will be remembered that the nerve lies within or beneath the supinator brevis and that it runs at right angles to the muscle fibers. About 4 cm. below the condyle the supinator brevis fibers should be divided parallel to their course and in this opening the flat nerve will be found.

The superficial *radial* nerve is the sensory terminal of the radial and is seldom if ever exposed for repair. It is, however, used as a graft for repairing continuity defects. It may be exposed by an incision which begins just above the bend of the elbow, midway between the biceps tendon and the external condyle of the humerus (Fig. 164). It should be carried down the radial surface of the forearm parallel to the medial border of the brachioradialis which is retracted. The nerve passes along the under surface of this muscle.

To overcome a large defect in the continuity of the radial in its middle third, it may be necessary to transpose the nerve to the anterior surface of the humerus. The nerve is exposed and mobilized in the upper part of the arm. The motor branches to the triceps are given off at this level and must be saved. The nerve should be exposed in the lower third of the arm and mobilized upward from the antecubital fossa. The numerous motor branches near the elbow must be carefully safeguarded.

The nerve should be freed from the scar tissue or callus in which it is embedded, but the neuromas on the central and distal ends should not be removed until the nerve has been transposed. Identification sutures should be placed in the sheath of the central and distal ends so that the nerve will not be rotated during the operation. The central end of the nerve should be withdrawn from the radial groove through the opening in the medial head of the triceps which it traverses normally. The distal end is passed in front of the humerus in a tunnel made beneath the brachialis anticus or it may be placed superficial to that muscle and beneath the biceps. The neuromas are resected and an end-to-end suture performed. Further relaxation may be obtained by flexion and adduction of the arm. By this method a defect of as large as 12 cm. may be bridged.

This method of transposition is to be used only in selected instances. If the nerve supply to the triceps muscle is endangered in the operation it should be abandoned since extension of the forearm is more valuable than extension of the wrist or fingers. The latter may be obtained, if necessary, by various tendon operations to be described later.

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